CALIFORNIA DIVISION OF MINES AND GEOLOGY

Fault Evaluation Report FER-82

January 5, 1979

1. Name of fault: La Nacion/Sweetwater fault zones.

2. Location of fault: La Mesa, National City and Imperial Beach 7.5 minute quadrangles, San Diego County (see figure 1).

3. Reason for evaluation: Part of 10-year program for fault evaluation.

4. List of references:

Artim, E.R., Bemis, C.G., Pinckey, C.J. and Smillie, B.R., 1971, Western San Diego County fault systems: Geological Society of America, Abstract with Programs (Cordilleran Section), v. 3, no. 2, p. 75.

Artim, E.R. and Pinckney, C.J., 1973, La Nacion fault system, San Diego, California: Geological Society of America Bulletin, v. 84, p. 1075-1080.
(Claims that Holocene soil broken by fault but no evidence given- no trench logs or descriptions of cuts or locations of observations.)

Elliott, W.J., 1977, New evidence concerning age of movement of the La Nacion fault, southwest San Diego County, California, in Farrand, G.T., editor, Geology of southwestern San Diego County, California and northwestern Baja, California; San Diego Association of Geologists, p. 53-58.
(A good report, it disprooves the contention of Artim and Pinckney (1973) that the La Nacion fault breaks Holocene soils. It is recommended that La Nacion fault be considered potentially active.)

Ellis, A.J. and Lee, C.H., 1919, The geology and ground water of the western part of San Diego County, California: U.S. Geological Survey Water Supply Paper 446, 321 p. (maps).
(Many photos of a very pristine landscape but no information on faults.)

Fairbanks, H.W., 1893, Geology of San Diego County; also of portions of Orange and San Bernardino Counties: California State Mining Bureau, Report 11, p. 76-120.

Fairchild Air Photos, 19 , 22930, 2-83, 84 and 85; 2-91, 92.
(On loan from Whittier College.)

Hanna, M.A., 1926, Geology of the La Jolla quadrangle, California: University of California Publications Bulletin of the Department of Geological Sciences, v. 16, no. 7, p. 187-246, map.

Hart, M.W., 1974, Radiocarbon ages of alluvium overlying La Nacion fault, San Diego, California: Geological Society of America Bulletin, v. 85, p. 1329-1332.
(Appears to give an abundance of hard evidence in addition to the age dating of soils.)

Hart, M.W., 1977, Landsliding, an alternative to faulting in San Ysidro, California, in Farrand, G.T., editor, Geology of southwestern San Diego County, California and northwestern Baja, California: San Diego Association of Geologists, p. 37-42.
(A fair argument but not so well illustrated as to be totally convincing. The possibility that faults might be there and implicated in the landslide seems to have been overlooked.)

Jennings, C.W., 1975, Fault map of California with locations of volcanoes, thermal springs and thermal wells: California Division of Mines and Geology, California Geologic Data Map Series, Map No. 1, scale 1:750,000.

Kennedy, M.P., 1968, Preliminary geologic map of a portion of northwestern San Diego City, California: California Division of Mines and Geology Open-File Resease 68-10, scale 1" = 800'.

Kennedy, M.P., 1973, Stratigraphy of the San Diego embayment, California: University of California, Riverside, unpublished Ph.D. Dissertation.

Kennedy, M.P., 1975, Character and recency of faulting, San Diego metropolitan area, California: California Division of Mines and Geology Special Report 123, 33 p., map 1:50,000.
(Although Holocene sediments are not known to be displaced by the Rose Canyon fault zone in the onshore part of the area, offshore subbottom acoustic profiles of the area between La Jolla and Oceanside, and of the San Diego Bay and immediate offshore shelf areas south of Point Loma, show that sediments of probqble Holocene age on the sea floor are displaced by faults that appear to be related to this zone (Moore, 1972; Moore and Kennedy, 1975).)

Kennedy, M.P. and Tan, S.S., 1977, Geology of National City, Imperial Beach and Otay Mesa quadrangles, southern San Diego metropolitan area, California: California Division of Mines and Geology Map Sheet 29, map 1:24,000.
(A good map of the La Nacion fault. No Holocene displacement shown or inferred. Text covers rocks but not structure.)

Liem, T.J., 1977, Late Pleistocene maximum age of faulting, southeast Mission Bay area, San Diego, California: in Farrand, G.T., editor, Geology of southwestern San Diego County, California and northwestern Baja,California: San Diego Association of Geologists, p. 61-64.
(No data on Holocene. Data removed by grading before discovery trench was cut.)

Milow, E.D., 1961, Guide to geologic field trip of southwestern San Diego County, in Thomas, B.E., editor, Field trip guidebook: Geological Society of America, 57th Annual Meeting (Cordilleran Section) p. 23-43.

Moore, G.W., 1972, Offshore extension of the Rose Canyon fault, San Diego, California: U.S. Geological Survey Professional Paper 800-C, p. 113-116.
(Appears to offer strong evidence of Holocene activity on Rose Canyon fault zone.)

Moore, G.W. and Kennedy, M.P., 1970, Coastal geology of the California-Baja California border area: in Pacific slope geology of northern Baja California and adjacent Alta California; Geological guidebook for 1970 Fall field trip, Pacific Sections AAPG,SEPM, and SEG, p. 4-7.
(Suggests that Rose Canyon fault extends southward into Mexico. Leaves question of Holocene activity ("tectonic deformation") open.)

Moore, G.W. and Kennedy, M.P., 1975, Quaternary faults at San Diego Bay, California: U.S. Geological Survey Journal of Research, v. 3, p. 589-595.

Peterson, G.L., 1970, Quaternary deformation of the San Diego area, southern California: in Pacific slope geology of northern Baja, California and adjacent Alta, California; Geological guidebook for 1970 Fall field trip, Pacific Sections AAPG, SEPM and SEG, p. 120-126.
(A good discussion of the history of Quaternary faulting and deformation in the vicinity of the Rose Canyon fault zone based on geomorphologic evidence.)

Real, C.R., Parke, D.L. and Toppozada, T.R., 1977, Magnetic tape catalog of California earthquakes, 1900-1974: California Division of Mines and Geology.

Strand, R.G., 1962, Geologic map of California-San Diego-El Centro sheet: California Division of Mines and Geology.

Toppozada, T.R., Parke, D.L. and Higgins, C.T., 1978, Seismicity of California 1900-1931: California Division of Mines and Geology, Special Report 135, 39 p.
(Showes a number of Intensity V-VI earthquakes in area of concern.)

Treet, R.L., 1977, Texas Street fault, San Diego, California: in Farrand, G.T., editor; Geology of southwestern San Diego County, California and northwestern Baja, California: San Diego Association of Geologists, p. 45-51.
(A well documented but rather long winded description of a fault possibly relatable to La Nacion and concluded not to display Holocene activity. Recommends further investigation because the fault is not exposed.)

Weber, F.H., Jr., 1963, Geology and mineral resources of San Diego County, California: California Division of Mines and Geology County Report 3, 309 p.

Wehmiller, J.F. and others, 1977, Correlation and chronology of pacific coast marine terrace deposits of continental United States by fossil amino acid stereochemistry-technical evaluation, relative ages, kinetic model ages, and geologic implication: United States Geological Survey Open-File Report 77-680, 106 p.

Wehmiller, J.F. and others, 1978, Amino-acid recemization dating of Quaternary mollusks, Pacific Coast United States: in Zartman, editor; Short papers of the fourth international conference, geochronology, cosmochronology, isotope geology, United States Geological Survey Open-File Report 78-701.
(Explains a very useful means of dating coastal, marine terrace deposits. Dates Point Loma 121,000 ± 7,000 years.

Wood, H.O., 1916, California earthquakes: Seismological Society of America Bulletin, v. 6, no. 2, p. 55-180.

Ziony, J.I. and others, 1974, Preliminary map showing recency of faulting in coastal southern California: U.S. Geological Survey Miscellaneous Field Studies Map MF-585, 3 sheets, scale 1:250,000, booklet 15 p. (No indication of Holocene activity.)

5. Summary of available data on fault: Reference to these faults was made by Artim and others (1974) although names for the faults did not appear in print until 1973 (Artim and Pinckney) in a paper titled "La Nacion fault system, San Diego, California." The following is the abstract of that paper:

> La Nacion fault system is a series of moderate-to high-angle normal faults striking north roughly parallel to the coast line and is traceable by surface features from 33 km north of the Mexico-United States border. The fault system occurs in locally folded Tertiary and Quaternary sedimentary rocks. Vertical offset of Pleistocene sediments is as much as 85 m on a given fault branch, and for the fault system may be as much as 120 m. Geophysical evidence suggests the total offset for the fault system is 500 m. Offset of alluvium has been proved at two localities, and unexplained seismic activity may be associated with La Nacion fault system.

In addition, Kennedy (1975, p. 13) states:

> The La Nacion fault zone has a regional trend striking northwesterly, subparallel to the Rose Canyon (FER-80) and Point Loma (FER-81) fault zones---. Some of the individual faults within the zone, however, strike northeast. The zone is composed primarily of a large number of en echelon faults that are mostly Quaternary in age and dip-slip in nature. The largest of these are the La Nacion, Sweetwater, Murphy Canyon and Mission Gorge faults.

In their summary Artim and Pinckney conclude:

> Offset of Pleistocene sediments is as much as 85 m on a given fault system. Offset of Holocene alluvium has been proved at two localities with maximum age of offset set at 10,080 $\pm$ 190 years B.P. determined by carbon-14 dates of offset alluvium. The present contention is that La Nacion fault system should considered a potentially active, if not active, fault.

Although Artim and Pinckney include a geologic map in their paper they do not describe or locate the site of their data on faulted and dated Holocene alluvium.

Attachment #2

In 1974 Michael W. Hart (see appended copy of Hart's paper) concluded:

> Using the generally accepted definitions of an active fault, the La Nacion fault connot be classified as active at the localities studied. Evidence indicating no Holocene activity includes the absence of topographic expression and the presence of undisturbed Holocene and late Pleistocene alluvium overlying the fault zone.

On a map by Ziony and others (1974), showing recency of faulting in coastal southern California, the zones of the La Nacion and Sweetwater faults are shown. They are portrayed as active during the Quaternary but not the Holocene.

Apparently neither of Hart's (1974) two trenches were the same as those used by Artim and Pinckney. So, Elliot and Hart (1977) relocated the "Brandywine" trench of Artim and Pinckney, reopened it, and, with the aide of several other geologists, concluded that none of the exposed traces of the La Nacion fault showed offset in overlying Holocene paleosol or alluvium (see appended pages from report by Elliot and Hart, 1977). Attachment #3

Thus, there is a consensus against Holocene displacement on the La Nacion-Sweetwater fault zone. The work by Kennedy, from which Figures 1 and 2 are drawn, is part of the consensus. The numbered sites on Figure 1 are the figure numbers in Special Report 123 (Kennedy, 1975) copies of which are appended (attachment #1).

As can be seen on Figures 1 and 2, the faults in the La Nacion-Sweetwater zones are mainly northerly-trending, normal, down on the west.

The San Ysidro fault, shown at the south end of Figure 1, is included as a southern segment of the La Nacion-Sweetwater fault system as it was by Kennedy and Tan (1977). It differs mainly in its more northwesterly

average trend. It is normal, southwest side down. Some linear topographic features (see attachment #4) along the southwest margin of the Otay Mesa have been mapped as faults (Ziony, et al., 1974; Kennedy, 1975, 1977) and described (Kennedy, 1975) as possibly cutting Holocene landslide debris. Hart (1977) suggested that these "faults" might all be landslide features. Vertical stratigraphic separations could result from either mechanism and may well have been produced by both.

6. Interpretation of air photos: A brief examination of the lineament and landslide complex on the San Ysidro fault (Fairchild, 22930, 2-83, 84, and 85; 2-91, 92) (see conclusions below).

7. Field Observations: None.

8. Conclusions: Although Artim and Pickney (1973) state that the La Nacion fault cuts Holocene sediments, subsequent authors (Hart, 1974; Elliot and Hart, 1977; Kennedy, 1975; see figures 1 and 2; attachment #1, #2 and #3) have demonstrated that it does not. There is some unresolved doubt about the age, origin and relationship between lineaments, faults, and landslides on the San Ysidro fault at the south end of the La Nacion fault zone but air photos strongly suggest that landsliding has modified the fault zones rather than the other way around as suggested by Kennedy (1975). Therefore, the well-defined linaments where the San Ysidro fault follows the edge of the Otay Mesa (see attachment #4) probably have been generated by erosional processes. In other areas the La Nacion-Sweetwater fault zone is ill-defined.

9. Recommendations: Using present project guidelines, the La Nacion-Sweetwater fault zone should not be zoned because there is insufficient evidence of Holocene activity. No further work is recommended on the part of this projects personnel but farther investigations (especially those on the San Ysidro fault) should be monitored for new evidence.

10. Investigating geologists name: Richard B. Saul Date: 1-12-79

I agree with the recommendations.
Elliott
1/16/79

FER-82 Figure 2
from Kennedy (1975)

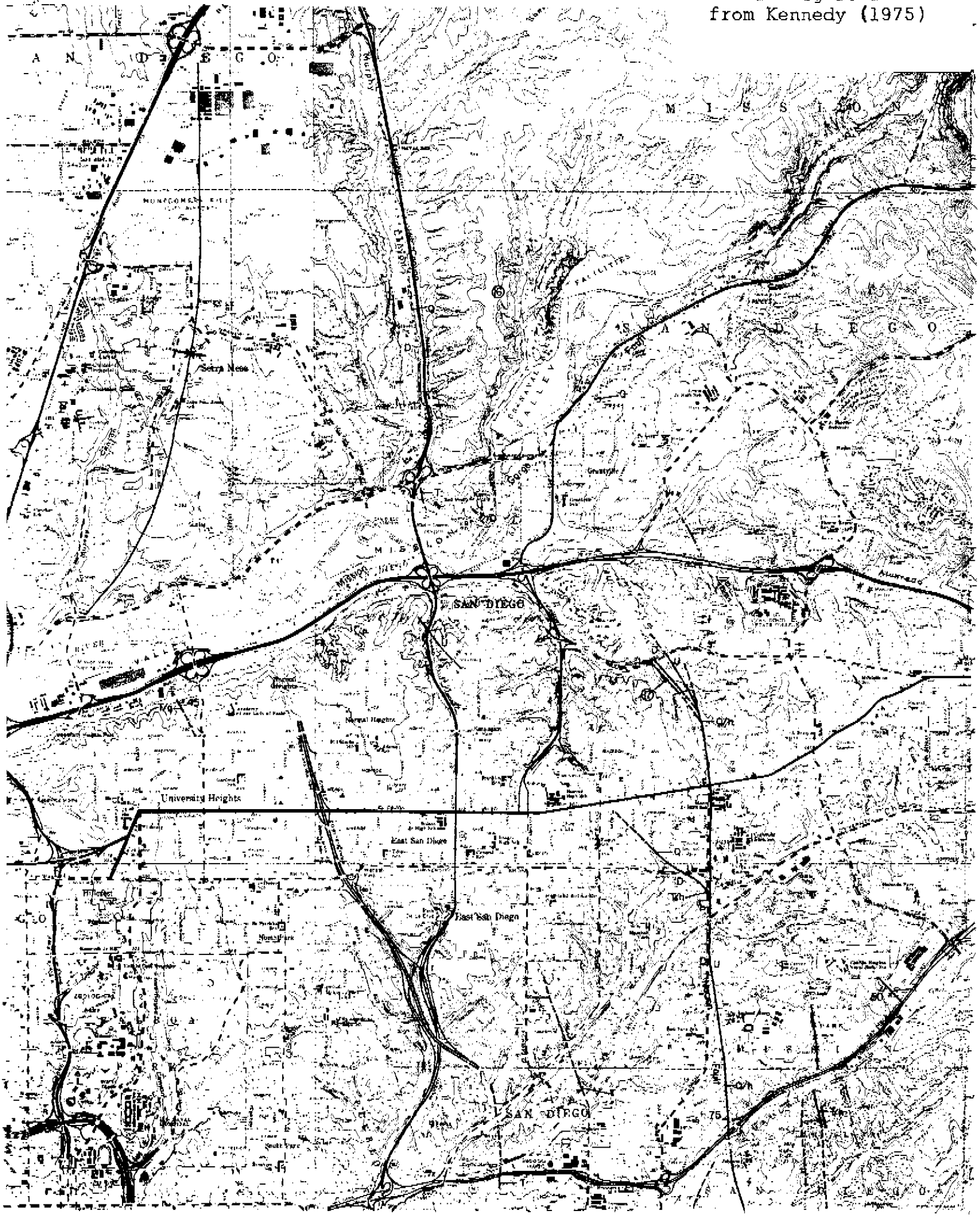


Figure 1
EXPLANATION

FAULT

Solid line where exposed or certain; dashed where [illegible]; dotted where concealed by Holocene alluvium. U, upthrown side; [illegible] side. Single arrow and number indicate dip of fault [illegible]; double [illegible] indicate sense of lateral slip.

FAULT [illegible]

FAULT INFERRED FROM TOPOGRAPHIC EVIDENCE

FAULT INFERRED FROM GEOPHYSICAL EVIDENCE
See plate 2 for magnetic, gravity and [illegible] data used for inference.

FAULT UNDER SAN DIEGO BAY AND OFFSHORE AREA
(Modified from [illegible] and Kennedy, in press).

SYNCLINE

ANTICLINE

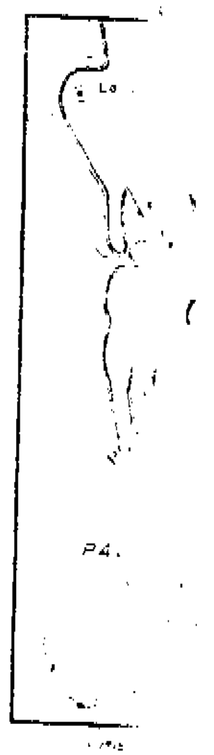
LOCATION OF TEXT FIGURE

T/H
AGE OF FAULT MOVEMENT

Capital letter indicates age of strata known to be faulted, lower case letter indicates age of strata known to be unfaulted. (See key below and text discussion of age of strata faulted and not faulted.)

Key to age of fault movement symbols

Strata and age	Faulted	Not faulted
HOLOCENE (Soil, alluvium, slopewash)	H	h
LATE PLEISTOCENE (Bay Point Formation)	L	
EARLY PLEISTOCENE (Lindavista Formation)	Q	q
TERTIARY OR OLDER STRATA (San Diego Formation, Otay Formation, Poway Group, La Jolla Group, Rosario Group)	T	t



FER-82 Attachment #1
Kennedy (1975) figures
Keyed by number to
Figure 1

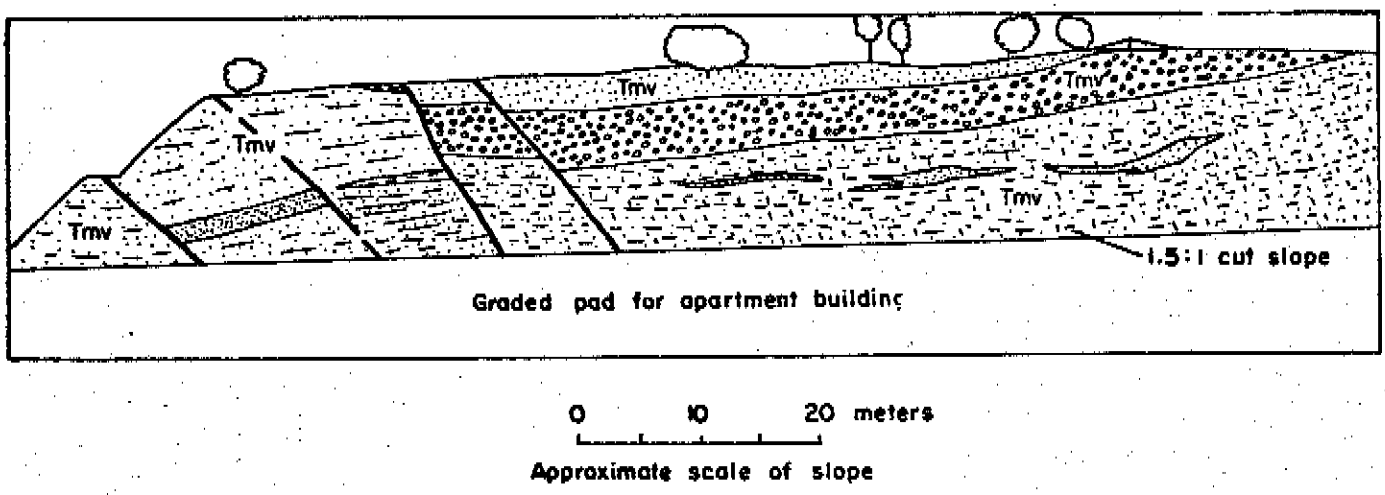


Figure 17. The La Nacion fault offsets strata of the Eocene Mission Valley Formation (Tmv). The Pleistocene Lindavista Formation is faulted by these same branch faults immediately south of this exposure. These are but a few of the small faults that constitute the northern end of the La Nacion fault in an area where the main trace of the fault is splaying into many parts. View north (see plate 1 for location).

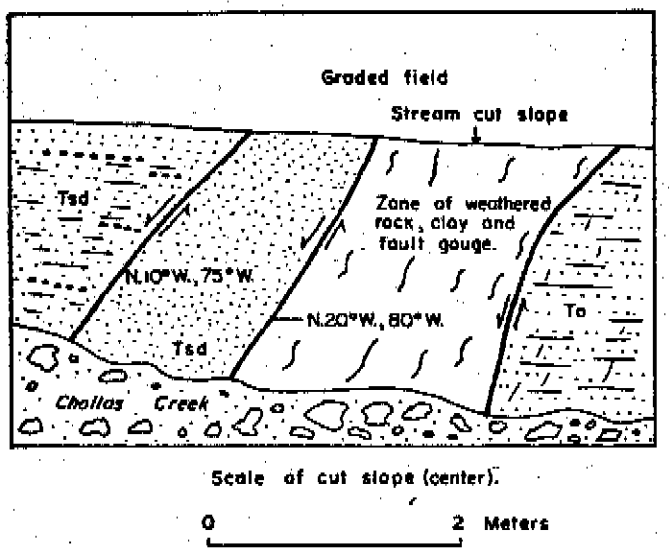


Figure 18. Rocks of the San Diego Formation (Tsd) downfaulted to the west (left) against rocks of the Otay Formation (To) along the La Nacion fault. View from Imperial Avenue where the curb and street are cracked. This cracking is considered to have resulted from settling within the fault zone rather than from direct tectonic origin. The same faults can be seen immediately north of this view in railroad cut. The fault zone within this area strikes N. 20° W., and dips to the W. 80°. View north (see plate 1 for location).

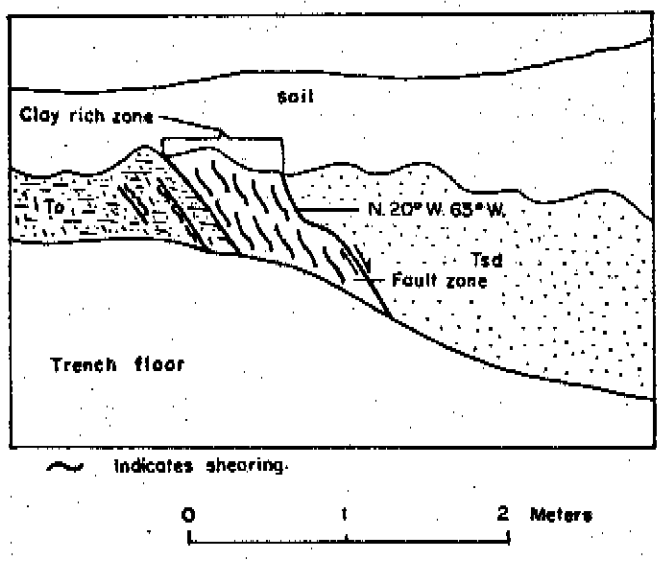


Figure 19. This fault lies within the La Nacion fault zone and juxtaposes rocks of the San Diego Formation (Tsd) and Otay Formation (To). A 1 m wide clay zone, containing numerous shears, is altered and deeply weathered material derived from the Otay Formation. The clay is montmorillonite and expansive. The top soil is not faulted but appears to have slumped into or to have been deposited along an old fault scarp. View south (see plate 1 for location).

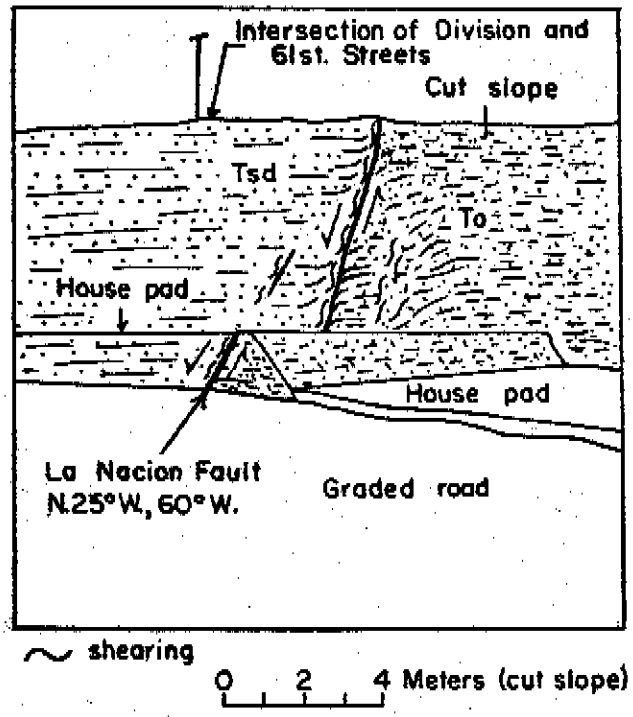
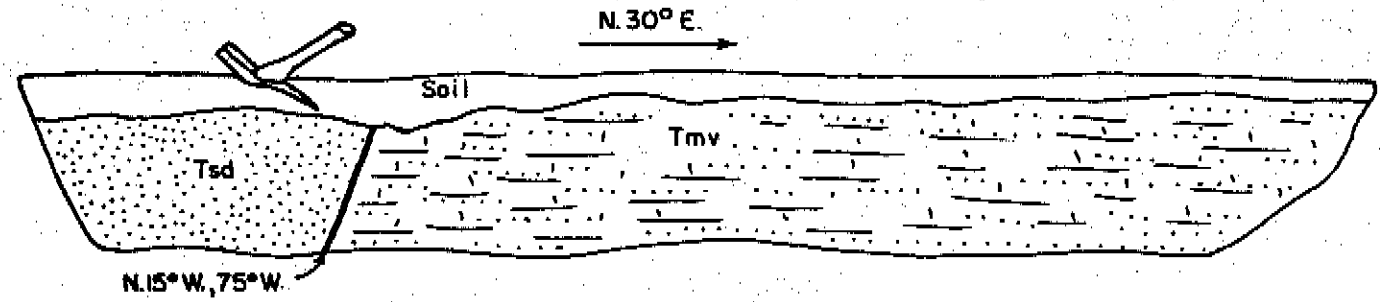


Figure 20. The La Nacion fault exposed in a newly graded housing development just south of the intersection between Division and 61st Streets. The San Diego Formation (Tsd) is downdropped to the west (left) and faulted against rocks of the Otay Formation (To). Rocks of the lower Pleistocene Lindavista Formation are faulted immediately north of this exposure. The vertical separation here since late Pliocene time is in excess of 75 m. View north (see plate 1 for location).



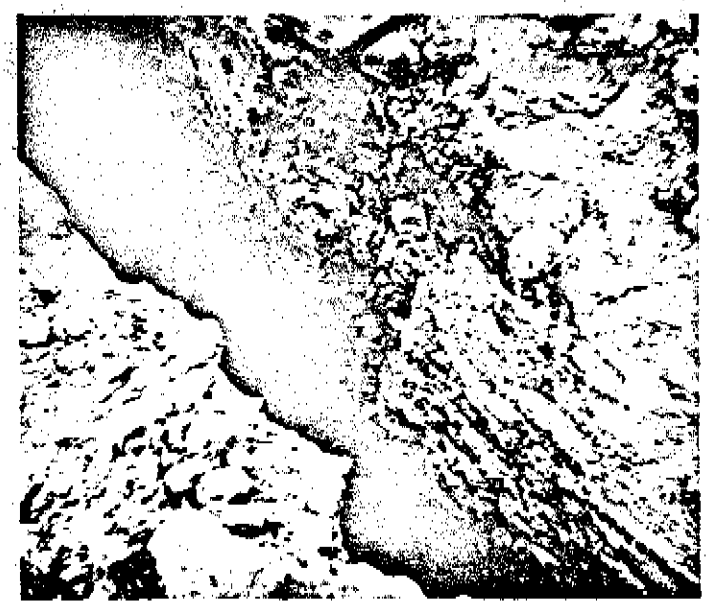


Figure 21. The La Nacion fault zone here juxtaposes rocks of the San Diego Formation (Tsd) and Otay Formation (To). The soil is not faulted. View northwest (see plate 1 for location).

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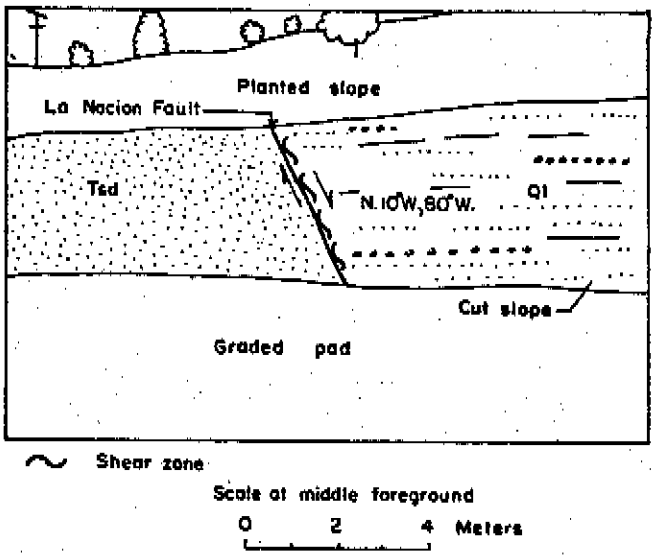


Figure 22. Branch of the La Nacion fault juxtaposes rocks of the San Diego Formation (Tsd) with lower Pleistocene deposits (Ql). The fault strikes N. 10° W. and dips 80° W. View south (see plate 1 for location).

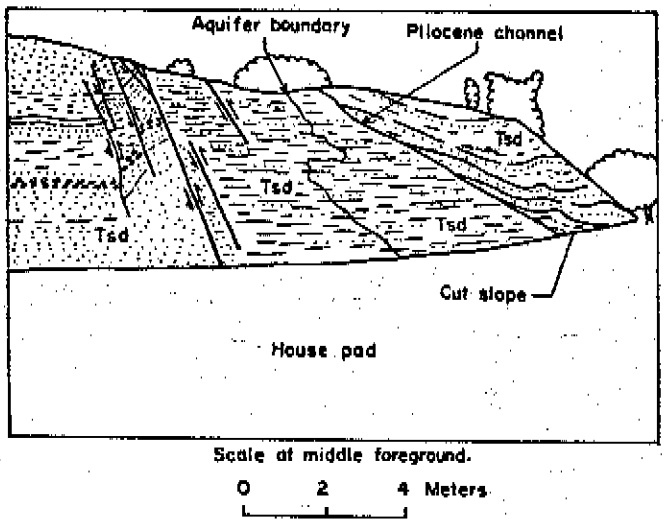


Figure 23. La Nacion fault zone juxtaposes rocks of the San Diego Formation (Tsd). Combined dip-slip separation of these faults is approximately 10 m. Rocks of early Pleistocene age are offset by these faults immediately north of this slope. View north (see plate 1 for location).

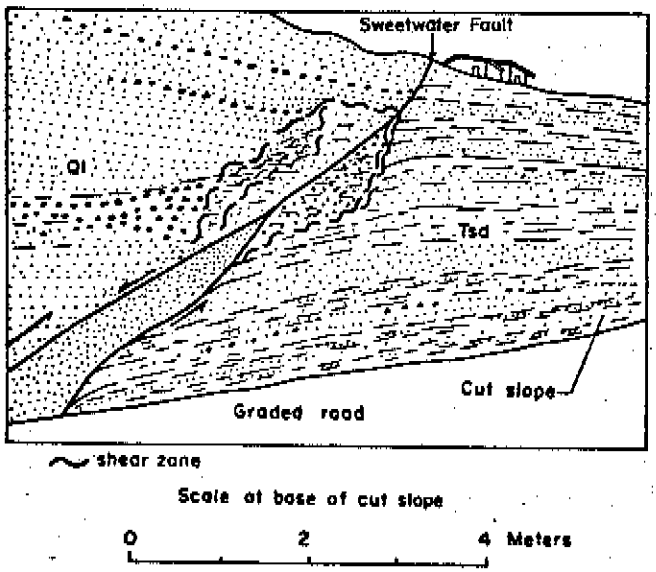


Figure 24. Lower Pleistocene strata of the Lindavista Formation (Ql) lie in fault contact with rocks of the San Diego Formation (Tsd). The Sweetwater fault at this location has several branches all displaying dip-slip separation. The total amount of separation here is in excess of 35 m. View north (see plate 1 for location).

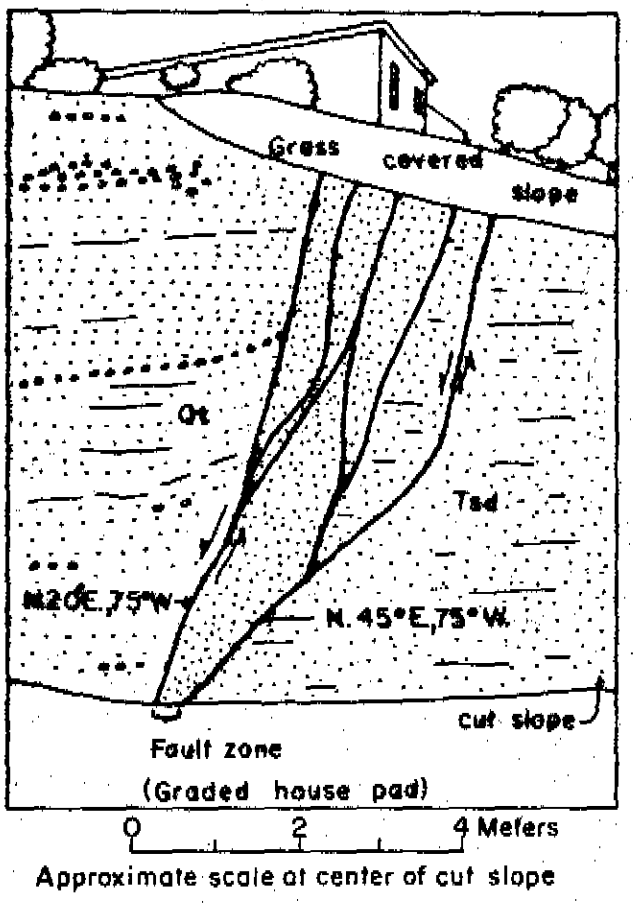


Figure 25. Multibranched segments of the Sweetwater fault juxtapose lower Pleistocene sediments (Qt) with upper Pliocene rocks of the San Diego Formation (Tsd). View north (see plate 1 for location).

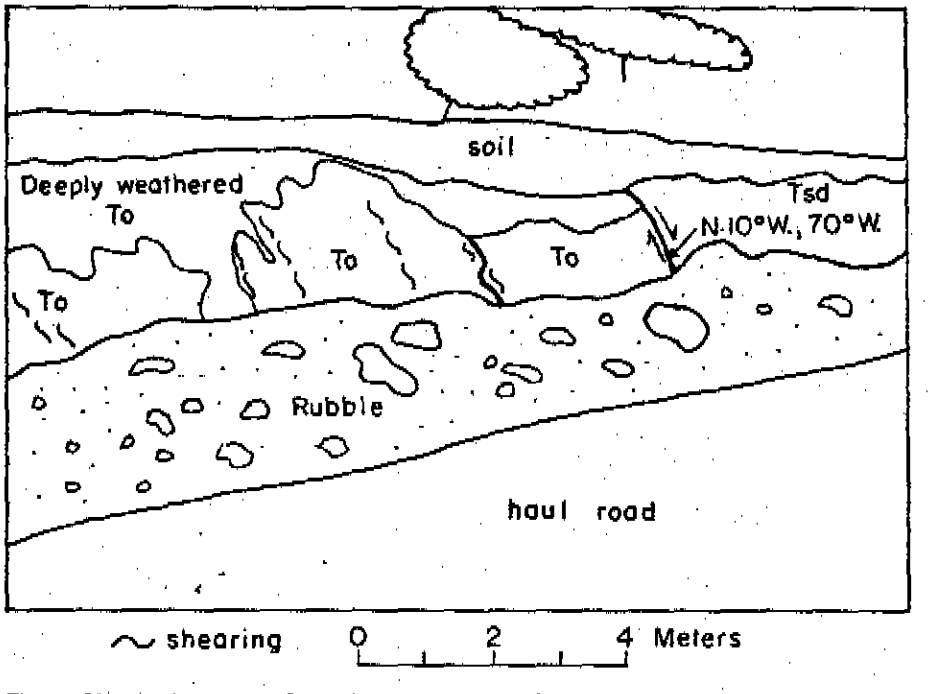
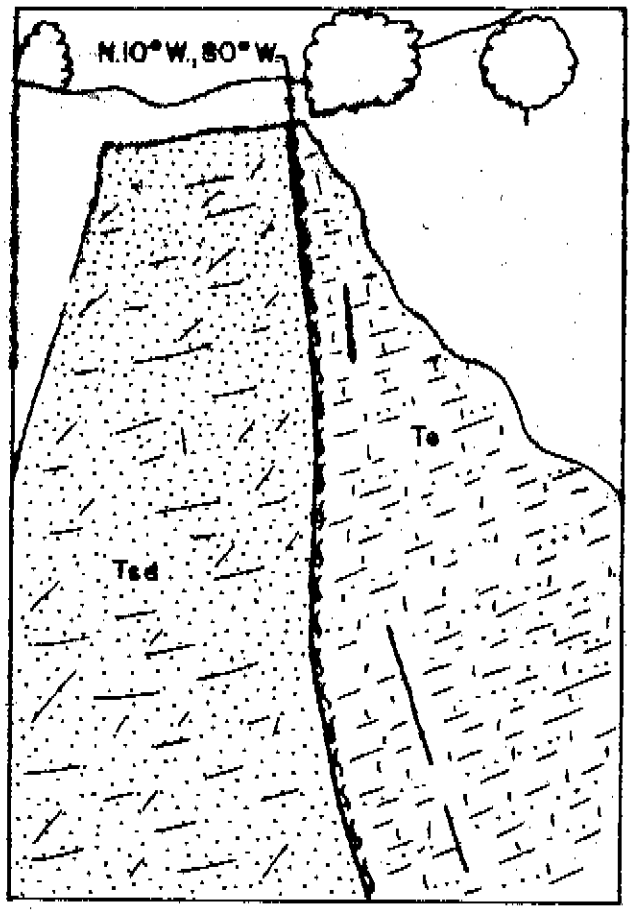


Figure 26. Rocks of the San Diego Formation (Tsd) lie in fault contact with deeply weathered sandstone beds of the Otay Formation (To). The weathered zone is predominantly caliche and clay. Soil and cobbles intermixed with the upper part of this zone are interpreted as Pleistocene ? soil or slopewash. The westernmost faults exposed strike approximately N. 10° W. and dip 70° W. The rubble is talus from the cut slope. View south (see plate 1 for location).



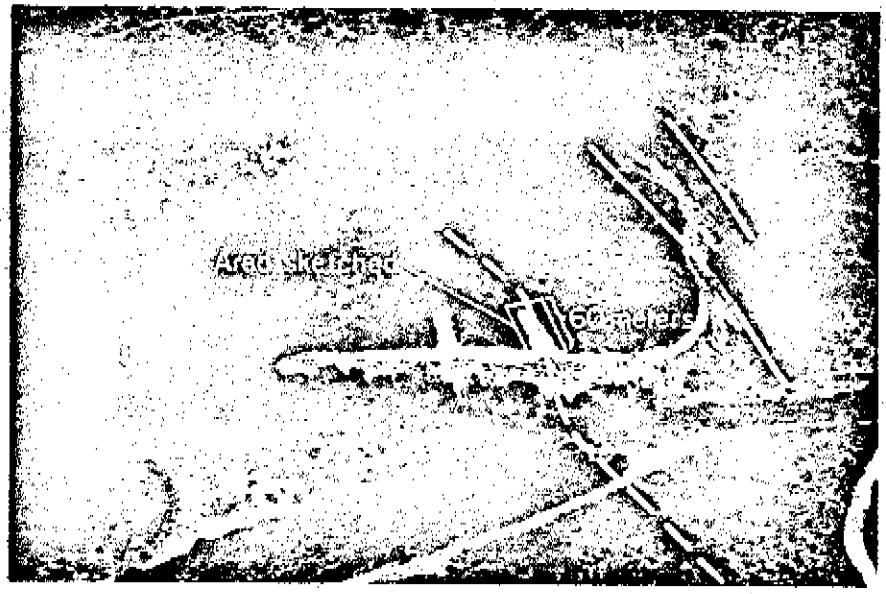


Figure 27. The La Nacion fault in floor of bulldozer excavation. The fault strikes N. 10° W. and dips 80° W. Rocks of the San Diego Formation (Tsd) are faulted down against rocks of the Otay Formation (To). The dip-slip separation measured on upper Pliocene strata is in excess of 75 m. Pleistocene rocks of the Lindavista Formation are not exposed here but are displaced by this fault less than 1 km to the south. View north (see plate 1 for location).

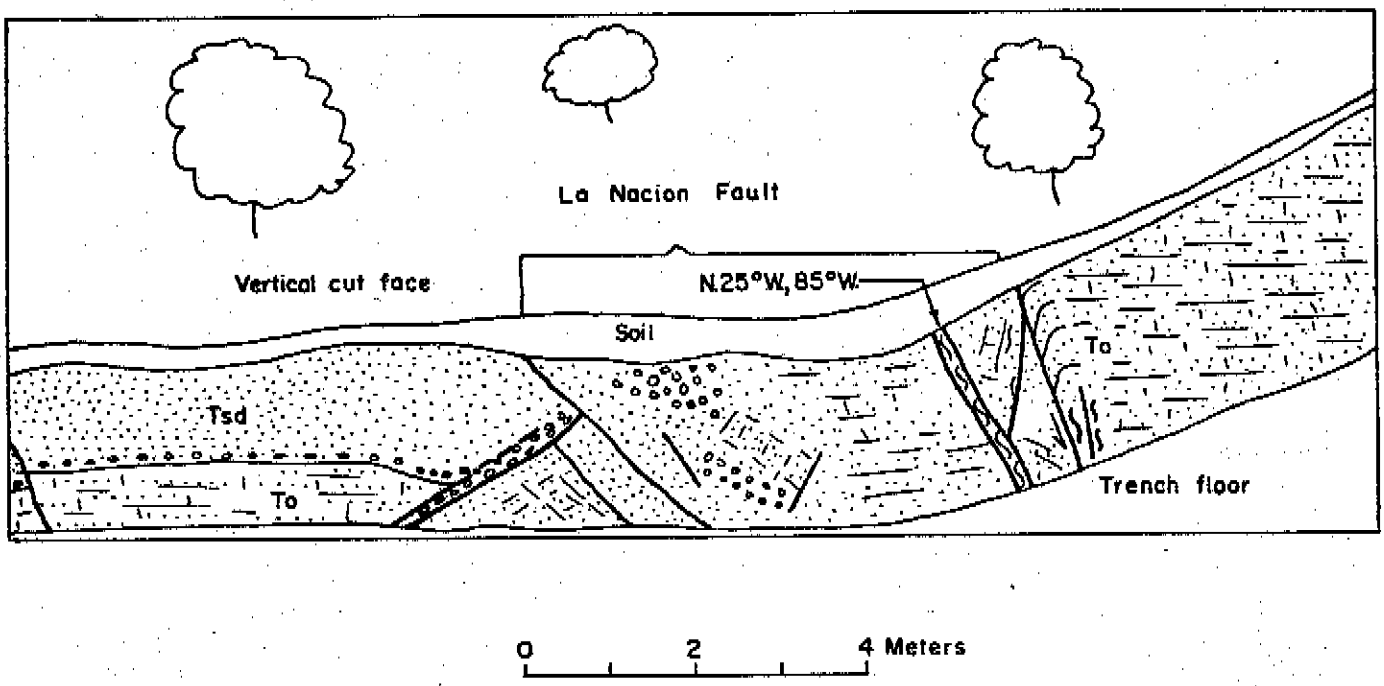


Figure 28. The La Nacion fault offsets the contact between the San Diego Formation (Tsd) and Otay Formation (To) approximately 7 m. The west side of the fault is down with respect to the east. View north in exploratory trench (see plate 1 for location).

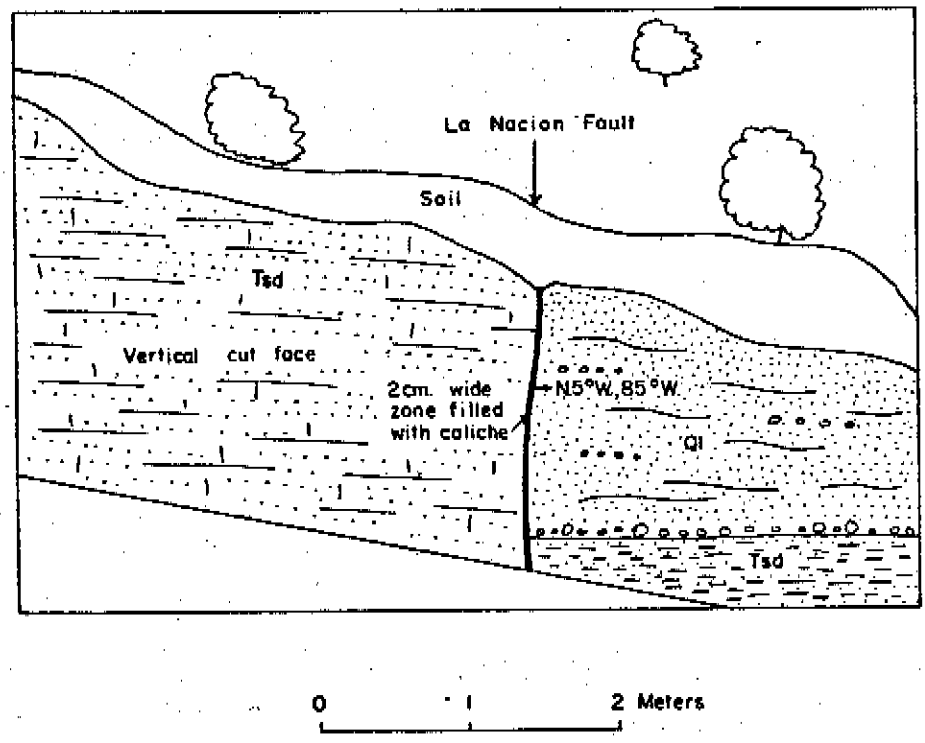


Figure 29. One of the faults within the La Nacion fault zone juxtaposes rocks of the San Diego Formation (Tsd) and Lindavista Formation (Ql). The dip-slip separation here has been 1.8 m since early Pleistocene time based on the net difference in elevation of the planar and horizontal base of the Lindavista Formation. The fault exposed in exploratory trench strikes N. 5° W. and dips 85° W. The zone of faulting is approximately 2 cm in width and no gouge is present. The fault surface is coated with caliche. Soil has been deposited in the upper 10 cm of fault zone but is not cut by the fault. View south (see plate 1 for location).

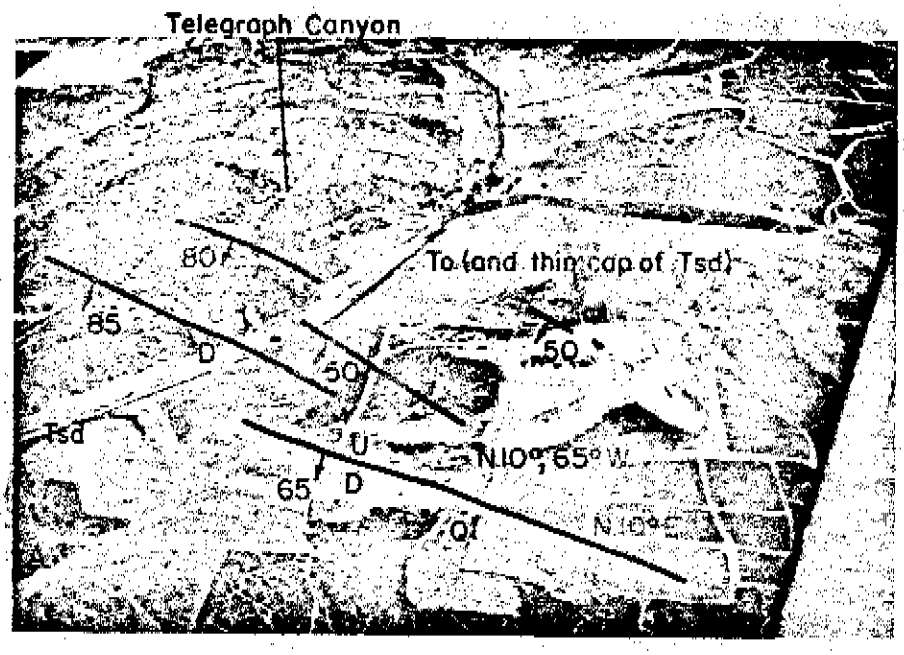
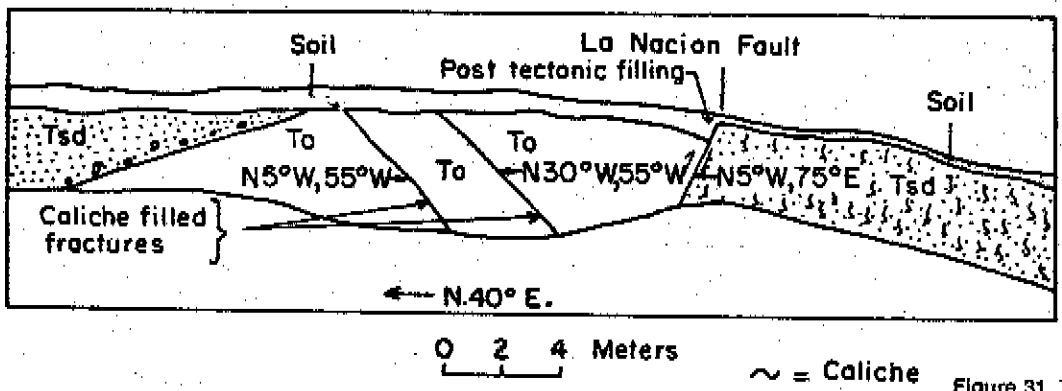


Figure 30. The La Nacion fault at Telegraph Canyon is offset or terminated by northeast striking faults (plate 1). Strata of the Tertiary Otay (To) and San Diego Formation (Tsd) are juxtaposed here. A thin cap of Lindavista Formation (Q1) is also faulted in this vicinity approximately 18 m. Air view northeast (see plate 1 for location).



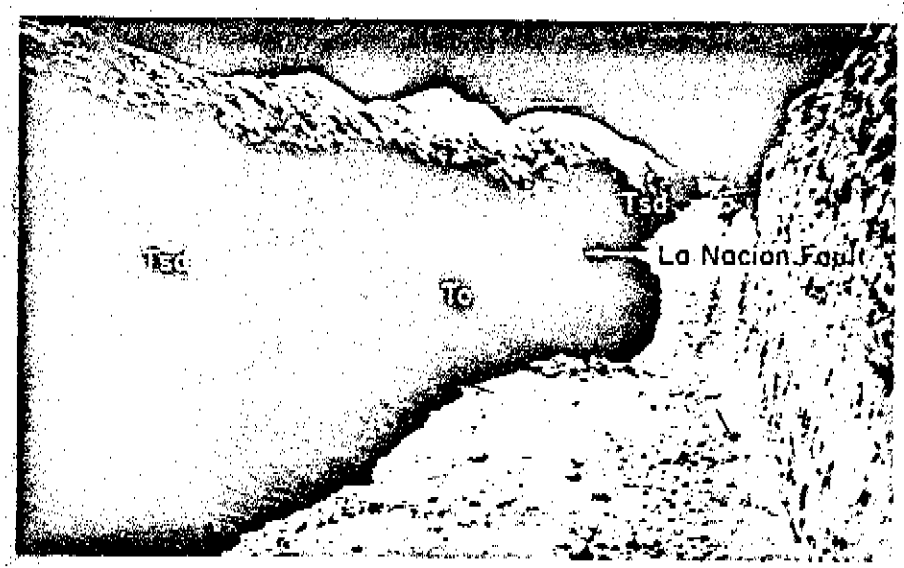


Figure 31. The La Nacion fault juxtaposes the San Diego Formation (Tsd) and Otay Formation (To). The fault strikes N. 5° W. and dips 75° E. The soil zone is not faulted but is thicker on the softer Otay Formation, probably as a result of (1) in situ soil development being more rapid in the Otay Formation than in the San Diego Formation, (2) the down slope migration of soil, and (3) infilling along an erosional fault scarp. The two small fractures within the Otay Formation show little or no displacement. They are filled with caliche which extends from the soil horizon, through expansion cracks, down into the bedrock. The San Diego Formation on the south side of the fault is deeply dissected by small caliche-filled fissures. The photograph shows the La Nacion fault on the opposite wall of the trench shown in sketch drawing. View looking east (see plate 1 for location).

FER 82

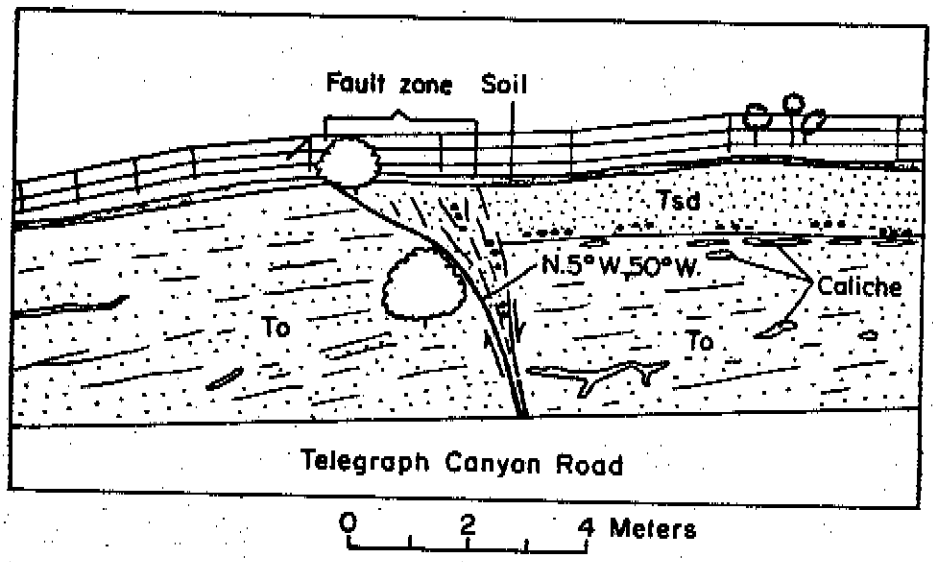


Figure 32. The La Nacion fault juxtaposes the San Diego Formation (Tsd) and the Otay Formation (To). Rocks within the fault zone are lithologically similar to those on the west side of the fault in the San Diego Formation. The fault strikes N. 5° W. and dips 50° W. The soil horizon that caps this cut along Telegraph Canyon Road is not displaced by the fault. The vertical separation measured is dip-slip in nature and on the order of 10 m in extent. View looking south (see plate 1 for location).

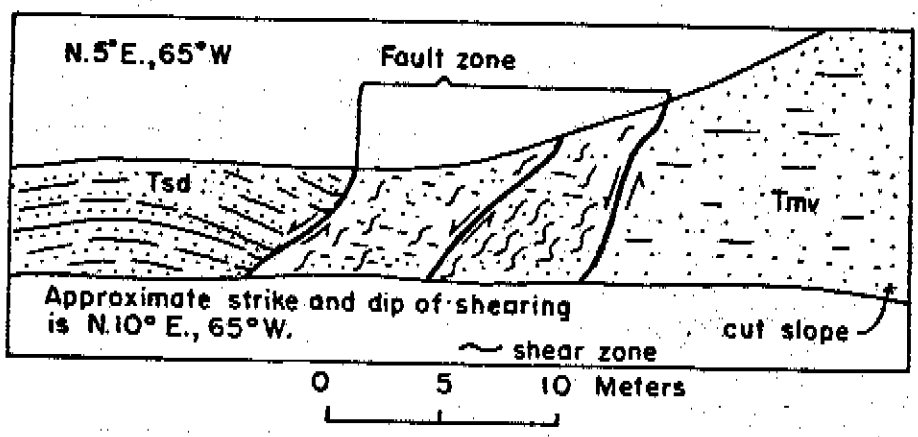


Figure 33. Rocks of the San Diego Formation (Tsd) are downdropped on the west (left) and faulted against rocks of the Mission Valley Formation (Tmv). Immediately north of this area the Pleistocene Lindavista Formation is offset about 10 m. The maximum separation here is dip-slip in nature and on the order of 50 m since late Pliocene time. View north at Poggi Canyon (see plate 1 for location).

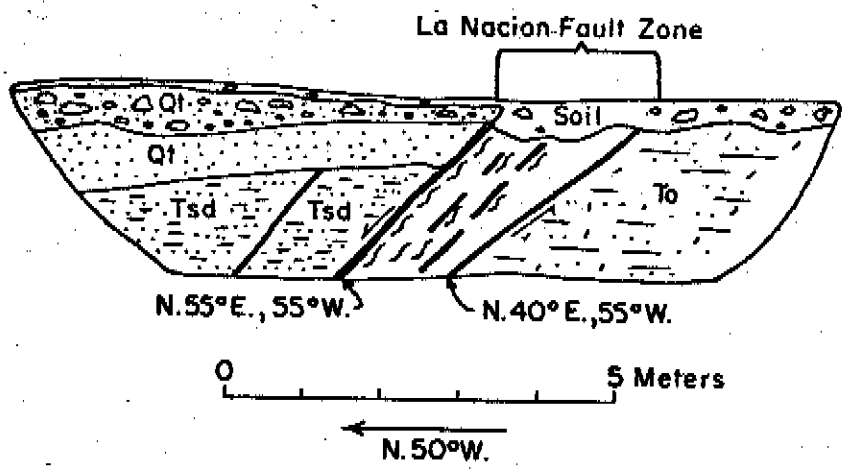


Figure 34. La Nacion fault zone, where Pleistocene nonmarine terrace deposits (Qt) and strata of the Pliocene San Diego Formation (Tsd) are juxtaposed with rocks of the Miocene Otay Formation (To). The soil overlying the Otay Formation is thicker than that overlying the Pleistocene terrace deposits but is not faulted. View north in exploratory trench (see plate 1 for location).

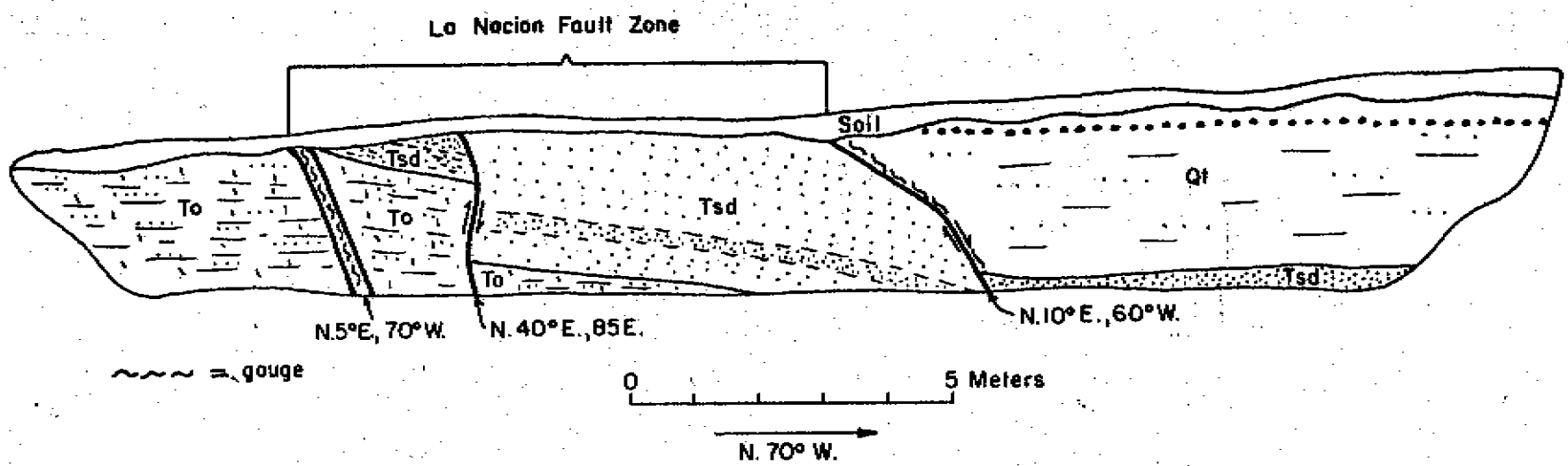


Figure 35. Juxtaposed strata of the Tertiary Otay (To) and San Diego Formations (Tsd) with Quaternary (?) age terrace deposits (Qt). View south in exploratory trench (see plate 1 for location).

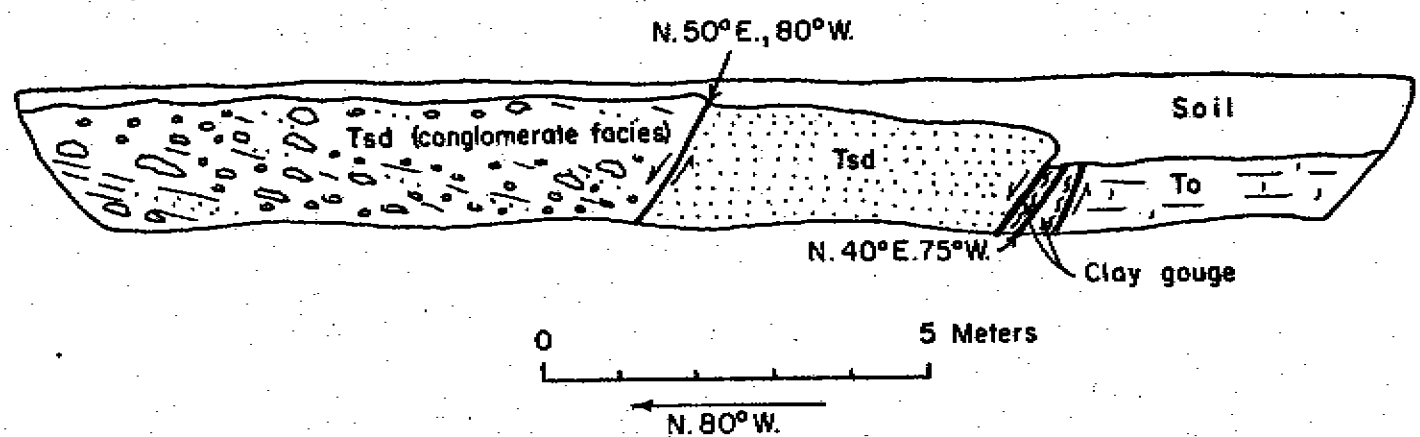


Figure 36. Strata of the San Diego Formation (Tsd) is faulted against the Otay Formation (To). The average strike of faults within the zone here is N. 40° E. and the dip is approximately 75° W. The soil horizon is thicker over the clay rich Otay Formation but is not faulted. View north in exploratory trench (see plate 1 for location).

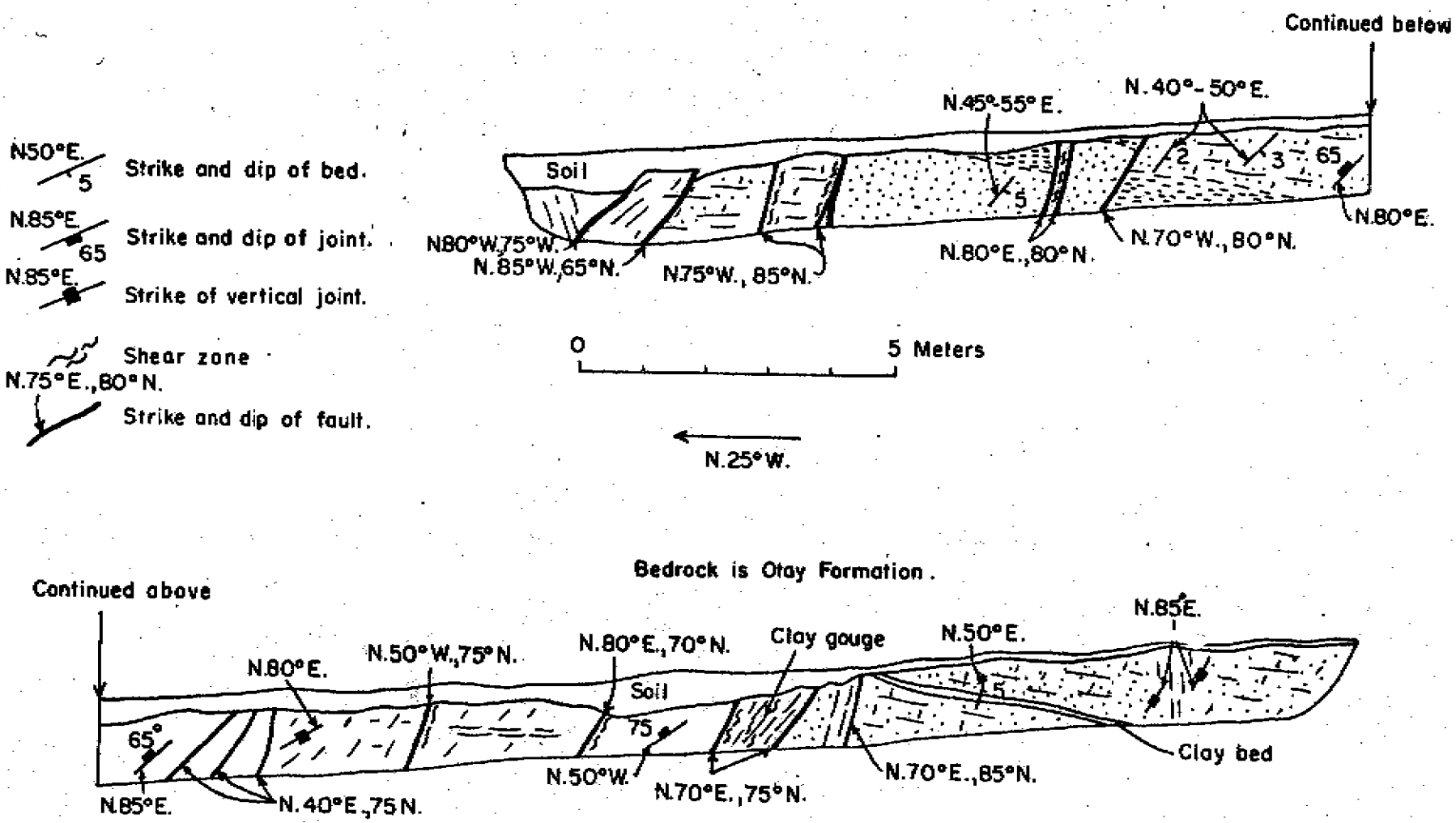


Figure 37. East-west striking faults intersect the La Nacion fault 1 km south of Otay Valley and may control the abrupt change in strike of the La Nacion fault here. View east in exploratory trench (see plate 1 for location).

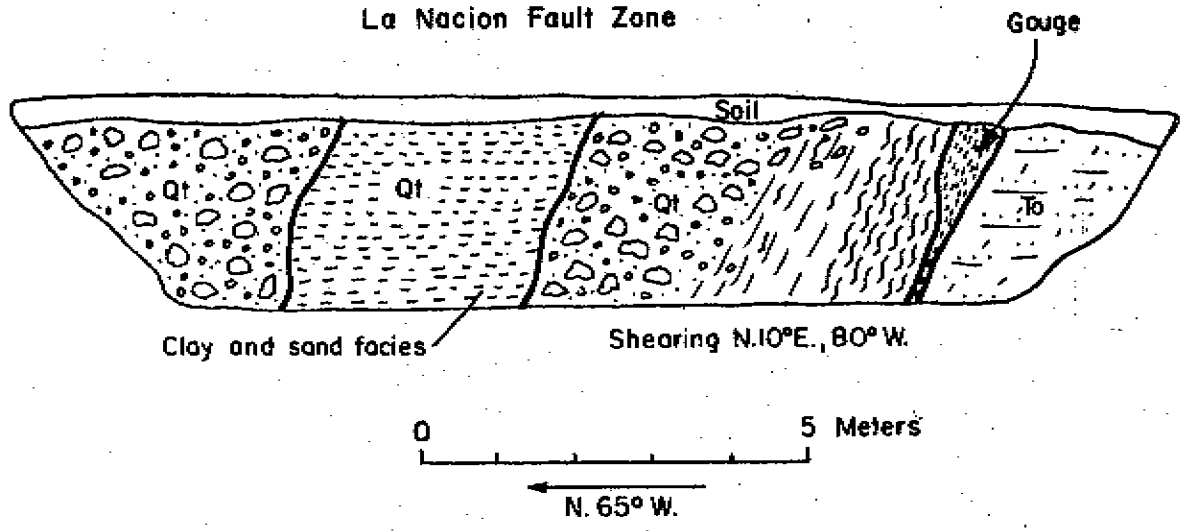


Figure 38. Quaternary terrace gravel and sand (Qt) are juxtaposed across a fault zone 3-4 m wide with rocks of the Otay Formation (To). Faults within the terrace deposits juxtapose a gravel and sand facies with a clay and sand facies. The average strike and dip of shearing within the fault zone is N. 10°E., 80°W. View north in an exploratory trench (see plate 1 for location).

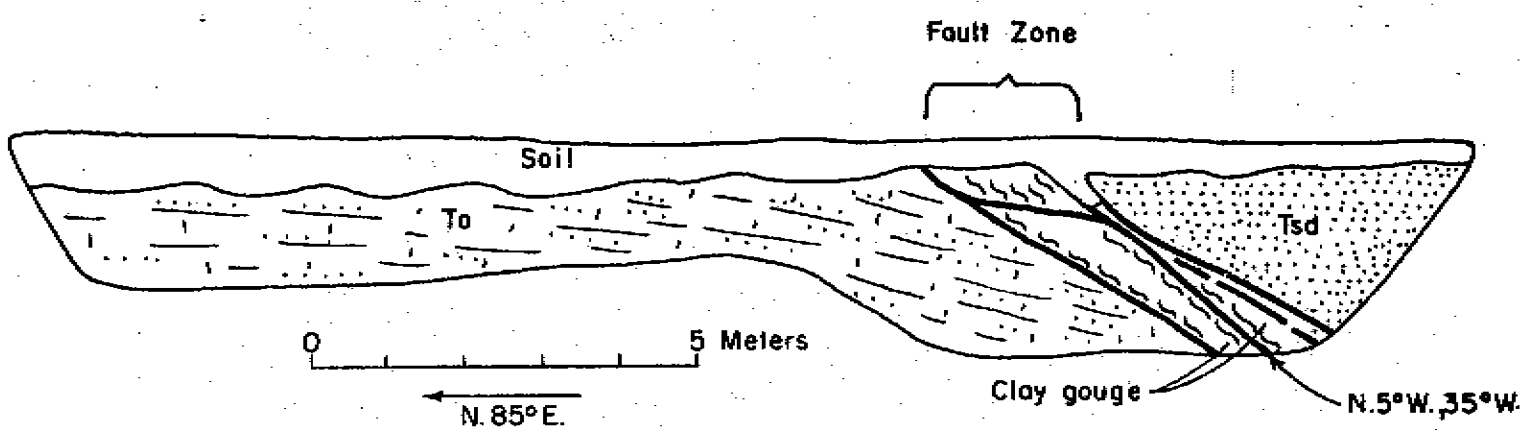


Figure 39. Juxtaposed San Diego Formation (Tsd) and Otay Formation (To). Soil lies adjacent to one branch of the fault as questionably the result of differential erosion along the fault plane and later deposit of soil. The soil horizon is extensively burrowed by animals and its contact with the underlying bedrock is not sharp. The apparent faulted soil horizon might be related to the burrowing. The average strike of the fault within the zone is N. 5° W. and the dip on an average 35° W. View south in an exploratory trench (see plate 1 for location).

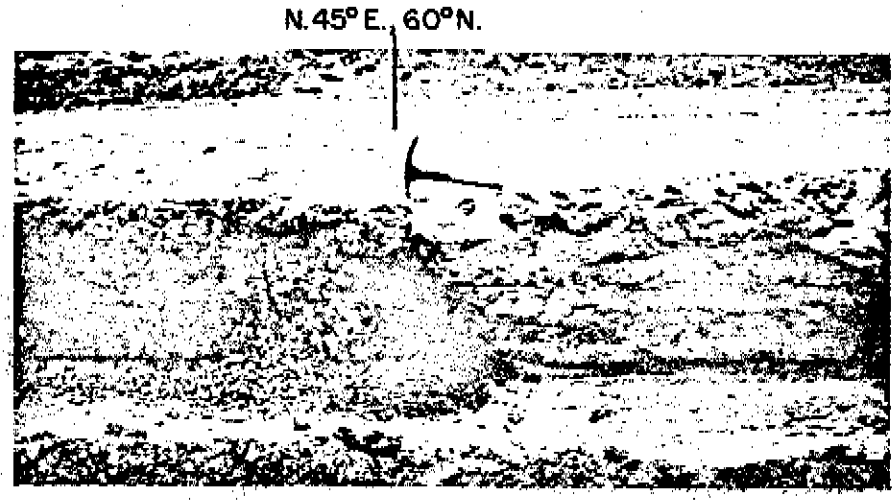


Figure 40. Faulted Quaternary terrace deposits vertically offset 2 m here. View west along Interstate Highway 805 (see plate 1 for location).

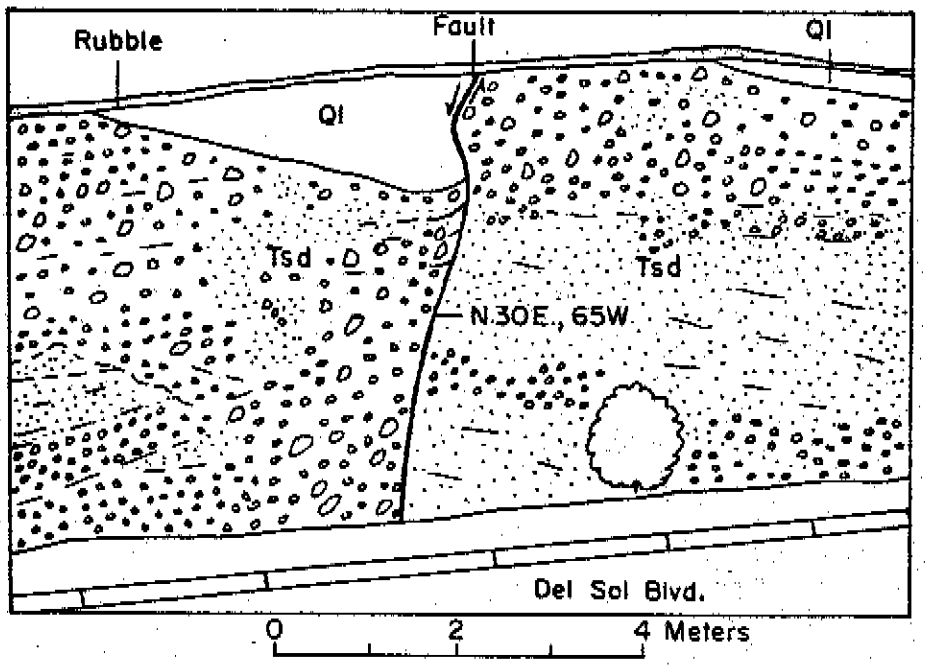


Figure 41. Road cut for Del Sol Boulevard. The Lindavista Formation (Ql) is vertically offset 2 m and is faulted against rocks of the San Diego Formation (Tsd). The fault strikes N. 30° E. and dips 65° W. View north (see plate 1 for location).

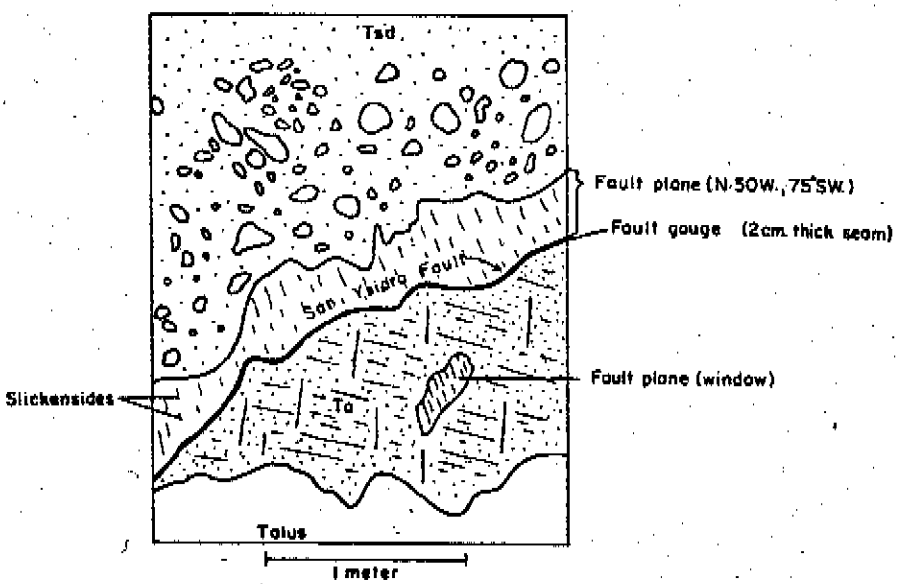


Figure 42. The San Ysidro fault juxtaposes strata of the San Diego (Tsd) and Otay (To) Formations. Approximately 30 m of vertical separation has occurred here with respect to these rocks. View west in rock quarry (see plate 1 for location).

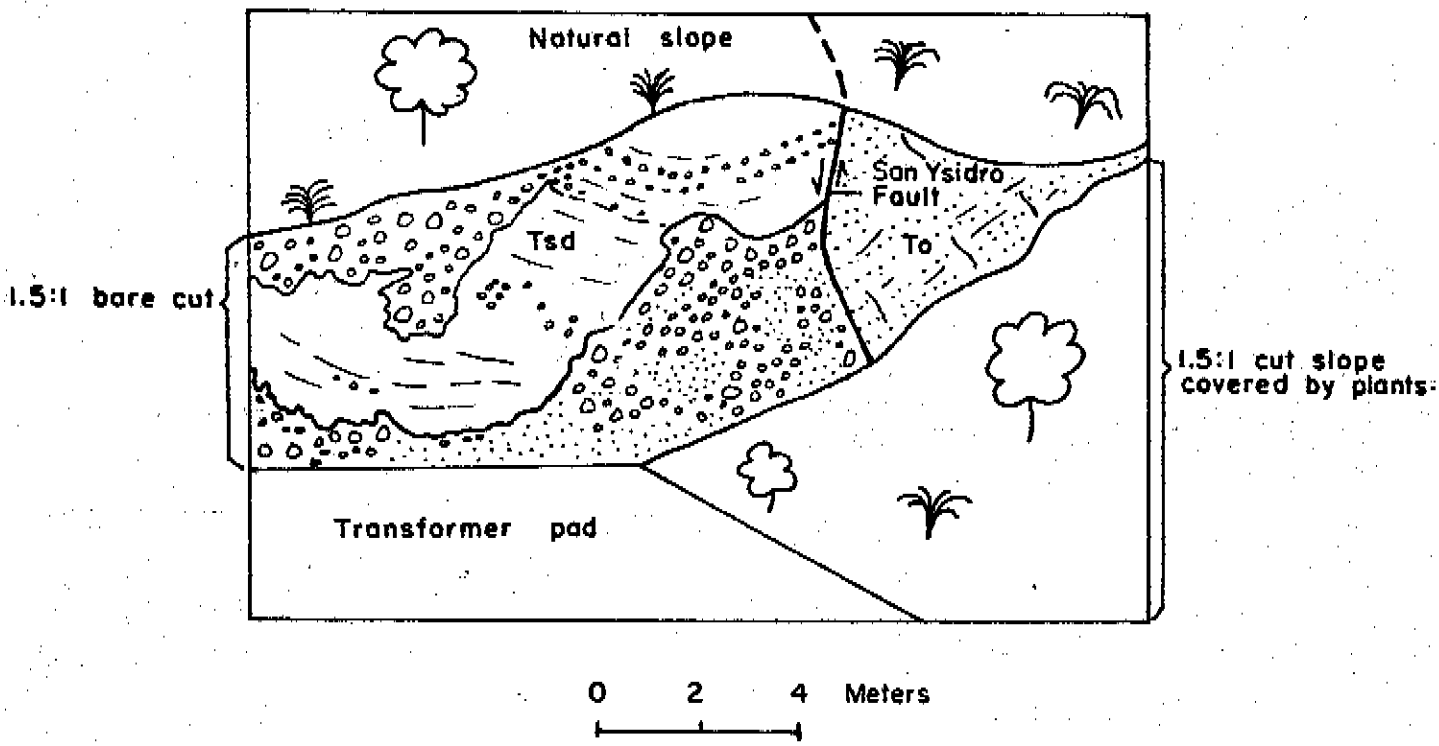


Figure 43. Rocks of a conglomeratic facies of the San Diego Formation (Tsd) lie in fault contact with sandstone of the Otay Formation (To). Approximately 70 m of vertical separation is associated with this break. The fault strikes N. 35° W. and dips 75° W. The west side of the fault is downdropped with respect to the east side. View north (see plate 1 for location).

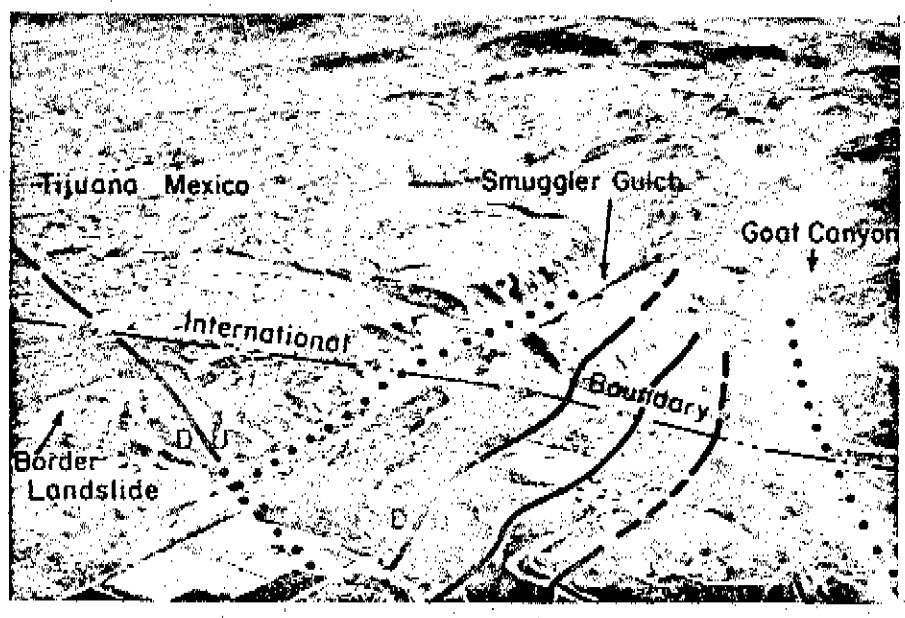


Figure 44. North and northwest striking faults show offset rocks of the Lindavista Formation. The fault shown adjacent to the Border Landslide juxtaposes rocks of the San Diego Formation and Lindavista Formation. The vertical separation there is on the order of 35 m. The three faults shown on the mesa between Smuggler Gulch and Goat Canyon together constitute the northern part of the Los Buenos fault mapped by Minch (1967) in Mexico. The faults shown are solid lines where accurately located, dotted where buried beneath unfaulted sediments, dashed where inferred. View south.

FER-82 Attachment #2

Radiocarbon Ages of Alluvium Overlying La Nacion Fault, San Diego, California

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ABSTRACT

Radiocarbon dates obtained from undisturbed alluvium overlying the La Nacion fault in the San Diego area indicate that the fault has not been active during Holocene time. The minimum age of alluvium at Poggi Canyon is 13,375 ± 275 yr B.P. This does not agree with the findings of a previously published report that indicates an offset of 1 m in alluvium dated at 10,980 ± 190 yr B.P.
Key words: environmental geology, faulting, radiocarbon dating.

INTRODUCTION

The purpose of this paper is to present new information on the age of the La Nacion fault in San Diego County, California. This information was obtained during exploratory excavations for urban development between November 1972 and July 1973. The dates were obtained from carbonaceous alluvium that overlies separate branches of the La Nacion fault in two widely separated areas. One site was located in Paradise Valley in San Diego, and one was located in Poggi Canyon in Chula Vista (Fig. 1). The radiocarbon ages were determined by Geochron Laboratories of Cambridge, Massachusetts.

A radiocarbon date of 10,980 ± 190 yr B.P. was obtained by Artim and Pinckney (1973) from alluvium reportedly offset 1 m in the Chula Vista area. The results of this study suggest that the faulting is older and predates the Holocene Epoch.

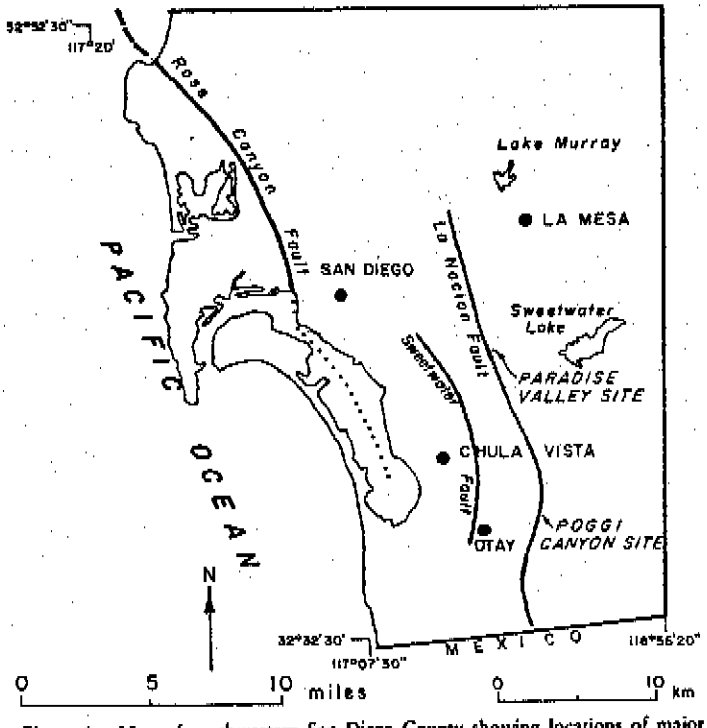

Figure 1. Map of southwestern San Diego County showing locations of major faults and study areas.

Geological Society of America Bulletin, v. 85, p. 1329–1332, 5 figs., August 1974

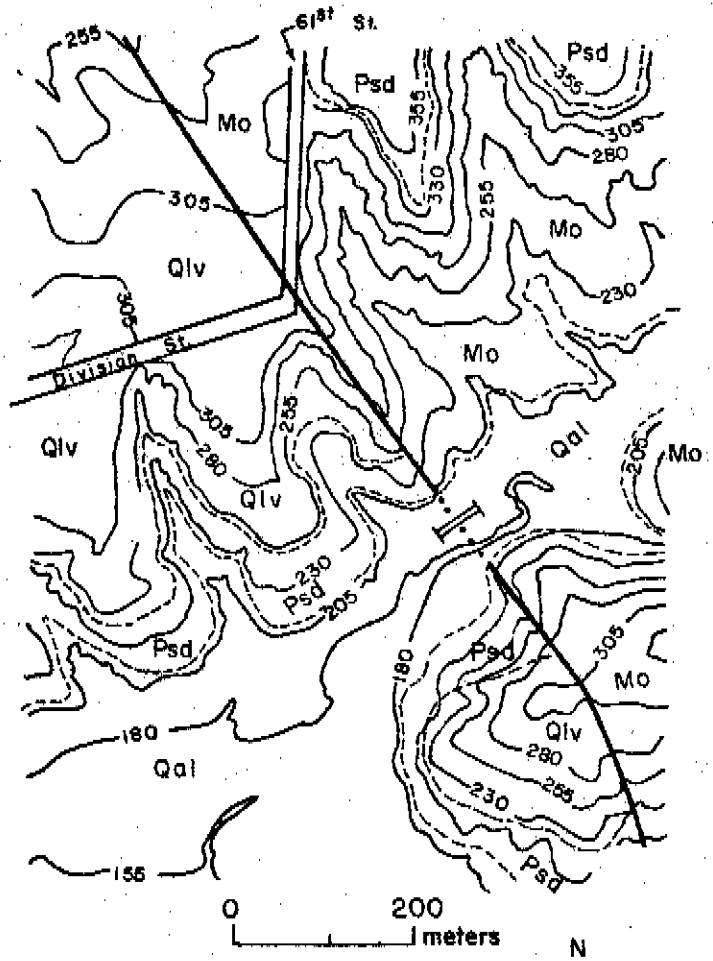

Figure 2. Geologic map of Paradise Valley site.

GEOLOGIC SETTING

The La Nacion fault extends north approximately 26 km from near the Mexican border through highly developed areas of San Diego, Chula Vista, and unincorporated areas of San Diego County. The fault typically separates the late Pliocene San Diego Formation on the west fror the (probably) Miocene Otay Formation on the east. The fault dips 60° to 75° W. and appears to have had principally dip-slip movement throughout its history. The minimum vertical separation based on measurements within the San Diego Formation is more than 60 m. Near its southern limits, the fault may also have displaced a Pleistocene marine terrace as much as 60 m (Artim and Pinckney, 1973). A nontectonic explanation for the possible terrace displacement is the original concept of the terraces as representing a classic example of remnants of a changing sea level. The La Nacion fault has displaced the Pleistocene Lindavista Formation more than 16 m at the Paradise Valley site.

Observations in exploratory trenches indicate that the fault is not a single clean break but is a zone of sheared and crushed rock that in places is more than 16 m wide. Within this fault zone, there are generally two major or primary faults forming the eastern and western limits of the zone of shearing. The easternmost break typically juxtaposes San Diego Formation and Otay Formation; the western break commonly separates Pleistocene terrace deposits and San Diego Formation.

Topographic evidence for Holocene faulting, such as sag depressions or well-defined fault scarps, have not been observed along the La Nacion fault. M. P. Kennedy (1974, oral commun.) has found faint lineaments, such as alignments of topographic saddles and canyons, along the trace of the fault. These features are attributed entirely to preferential erosion along the fault and not to Holocene activity.

PARADISE VALLEY SITE

The Paradise Valley site is located approximately 300 m south of the intersection of 61st Street and Division Street in San Diego. The La Nacion fault in this locality trends northwest and dips between 65° and 75° southwest. The fault was exposed in numerous exploratory trenches throughout the site. As can be seen on the location map (Fig. 2), the fault occupies the top of a narrow ridge. North of the site, the fault crosses a level marine terrace with no topographic expression of its presence.

Movement on the fault in the Paradise Valley locality has offset rocks of the Lindavista, San Diego, and Otay Formations. The minimum vertical separation of Pliocene and Pleistocene rocks is 45 m and 16 m, respectively.

In order to obtain material for dating the fault, a large bulldozer

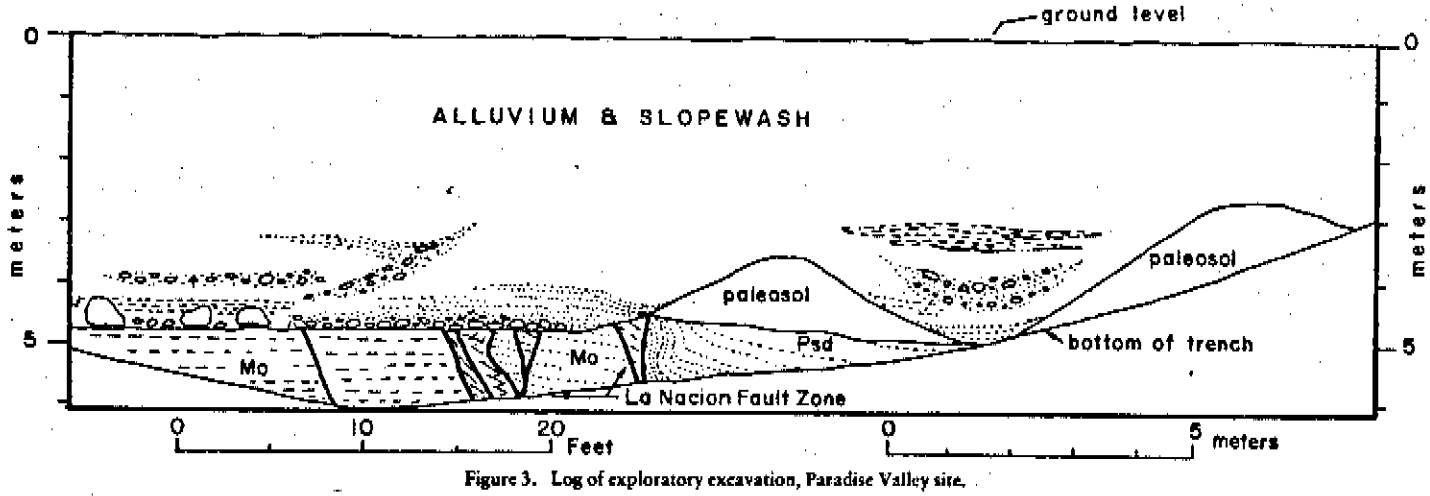

Figure 3. Log of exploratory excavation, Paradise Valley site.

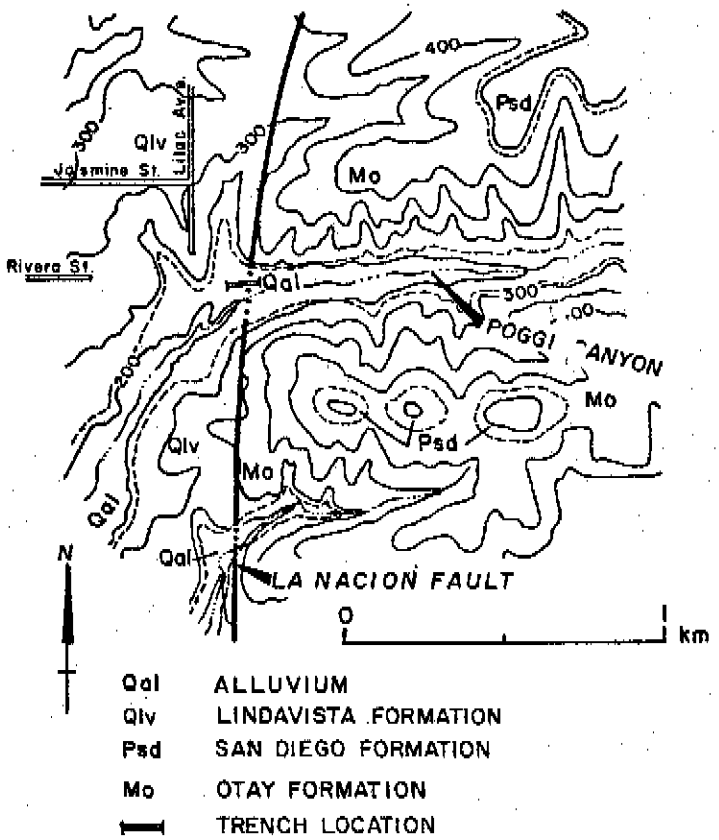

Figure 4. Geologic map of Poggi Canyon site.

trench, 6 m deep, was excavated in an alluvium-filled canyon shown on Figure 2. The alluvium exposed in the trench is 4.3 m thick and is underlain by the San Diego and Otay Formations in fault contact. The alluvial contact is exceptionally well defined here and is not disturbed by faulting (Fig. 3).

Two samples of alluvium were obtained from the trench for radiocarbon dating. Organic carbon in sample 1 was dated at 6,840 ± 390 yr B.P. Organic carbon in sample 2 was dated at 7,960 ± 530 yr B.P.

POGGI CANYON SITE

The Poggi Canyon site is located east of the present end of Rivera Street and south of Lilac Avenue in Chula Vista (Fig. 4). The canyon from which Holocene activity on the fault was reported by Artim and Pinckney (1973) is located 0.8 km to the south. Poggi Canyon, as shown by several auger borings made for this study, contains approximately 10 m of alluvium and slopewash materials.

At Poggi Canyon, the fault strikes N. 16° E., and dips 60° W. Beds of the San Diego Formation west of the fault dip as much as 21° E.; rocks of the Otay Formation on the east side of the fault are essentially flat lying. The Lindavista Formation crops out north and south of the exploratory trench (Fig. 5) and has been faulted against the Otay and San Diego Formations. The minimum vertical separation observed along the fault at this location is 67 m, measured from the base of the San Diego Formation.

The bulldozer trench from which the samples for radiocarbon dating were obtained was placed near the northern edge of the canyon where the alluvium was known to be only 8 m deep. The trench was dug to a depth of 4.6 m with a bulldozer, and a smaller trench 3 to 4.6 m deep was excavated inside the bulldozer trench with a backhoe. As indicated on the trench log (Fig. 5), the alluvial materials are not offset by faulting anywhere within the 14-m-wide fault zone.

Because the alluvium contained insufficient organic carbon for analysis, soil carbonate was used. Sample 1, taken from a depth of 8 m in a boring placed in the alluvium adjacent to the trench, resulted in a soil-carbonate age of 13,375 ± 275 yr B.P. Sample 2 was taken from a depth of 4 m in the same boring and resulted in a soil-carbonate age of 11,500 ± 400 yr B.P.

Soil carbonate is a chemical product of the weathering of feldspars. In arid climates, such as in southern California, leaching of these carbonates results in the formation of a zone of "caliche" several feet below the ground surface. The carbonates dated in Poggi Canyon formed in such a manner.

There are two types of errors unique to dating soil carbonate in alluvial sediments (Polach and Golson, 1966). The first type of error makes the sample appear younger than it actually is. The second type makes the sample appear older and is the primary concern in this study. The sample may appear older if it has been contaminated by detrital carbonate in the form of reworked fossil-shell debris. The primary argument against significant contamination by fossil-shell debris is that the soil samples yielded a radiocarbon date. If they had contained fossil-shell debris, no date would have been attainable because the upper limit of ^{14}C dating is approximately 40,000 yr.

Another form of detrital carbonate that could have contaminated the sample is caliche. This is considered unlikely because examination of the soil before dating showed no evidence of this type of contamination.

If the samples were contaminated at all, it is more probable that they would have been contaminated by younger carbonate. This could occur from percolating ground water at any time after deposition of the sampled horizon or from mixing of the sample with younger sediment during sampling.

If the soil carbonate formed in situ, then its radiocarbon age is younger than the age of the alluvium. The ages reported for the alluvium in Poggi Canyon would then be minimum ages. The close

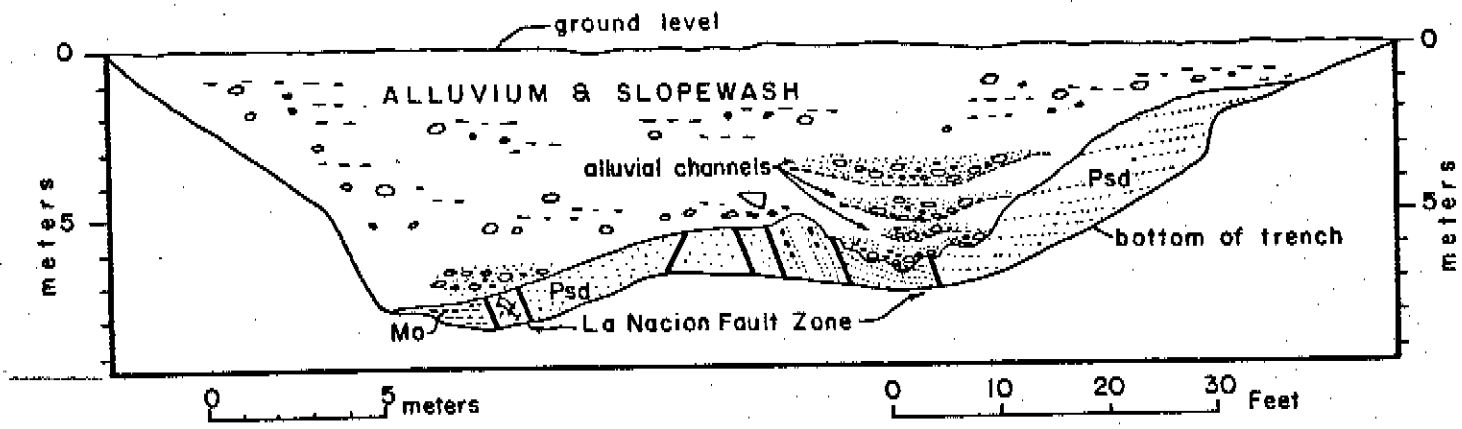

Figure 5. Log of exploratory excavation, Poggi Canyon site.

agreement between soil-carbonate ages obtained from alluvium in Poggi Canyon and organic carbon ages of alluvium from similar depths in nearby areas suggests that radiocarbon dates obtained from the soil carbonate are valid.

CONCLUSIONS

Using the generally accepted definitions of an active fault, the La Nacion fault cannot be classified as active at the localities studied. Evidence indicating no Holocene activity includes the absence of topographic expression and the presence of undisturbed Holocene and late Pleistocene alluvium overlying the fault zone.

ACKNOWLEDGMENTS

I thank Leslie D. Reed and Alfred N. Venton of William S. Krooskos and Associates who helped log the exploratory trenches and collect samples for the radiocarbon analyses. I also thank William J. Elliott, Michael R. Flynn, Dennis L. Hannan, and George W. Moore, who inspected the Poggi Canyon excavation and gave useful comments regarding geologic interpretation.

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MANUSCRIPT RECEIVED BY THE SOCIETY NOVEMBER 26, 1973
REVISED MANUSCRIPT RECEIVED MARCH 8, 1974

Figure 5. Several of the geologists who participated in the Brandywine trench logging. Front: W. J. Elliott, D. Hannan; rear: M. Hart, L. Erb (L. Erb Drilling Co.), R. Dowlen, T. Liem, D. Stickney, L. Reed, F. Kingery, A. Mayo, W. Ganus. Not in protograph: G. Gastil, B. Smyllie, Sgt. C. Cook, Jr., M. Chapin, and W. Catlin.

As the new excavation was limited to removing backfill material, the new south wall exposure was within a foot or so of the original one. It was therefore relatively easy to pinpoint and correlate features illustrated on the original trench log with the bedrock and soil exposed along the south wall of the re-excavated trench.

The new Brandywine trench was logged in detail at a scale of 1 inch equals 5 feet and is shown diagramatically in Figure 6. Results of this logging showed that: (1) the La Nacion fault consists of several distinct slickensided shear zones, (2) there is a main shear zone which juxtaposes light gray clayey siltstones of the Eocene/Miocene Sweetwater Formation (Eocene Mission Valley Formation of Kennedy, 1977) on the east against yellow fine-grained sandstones of the Pliocene San Diego Formation on the west, (3) a dark gray-brown clayey Holocene paleosol and brown sandy Holocene alluvium were deposited over the La Nacion fault on an irregular erosion surface, (4) neither the Holocene paleosol nor the sandy alluvium are displaced by the La Nacion fault, and (5) the age of the paleosol based upon radiocarbon analysis was determined to be 10,550±560 years B.P. (R. Berger, 1975, written communication).

Figures 7 and 8 show the unfaulted Holocene paleosol overlying the main trace (trace No. 1 on Figure 6) of the

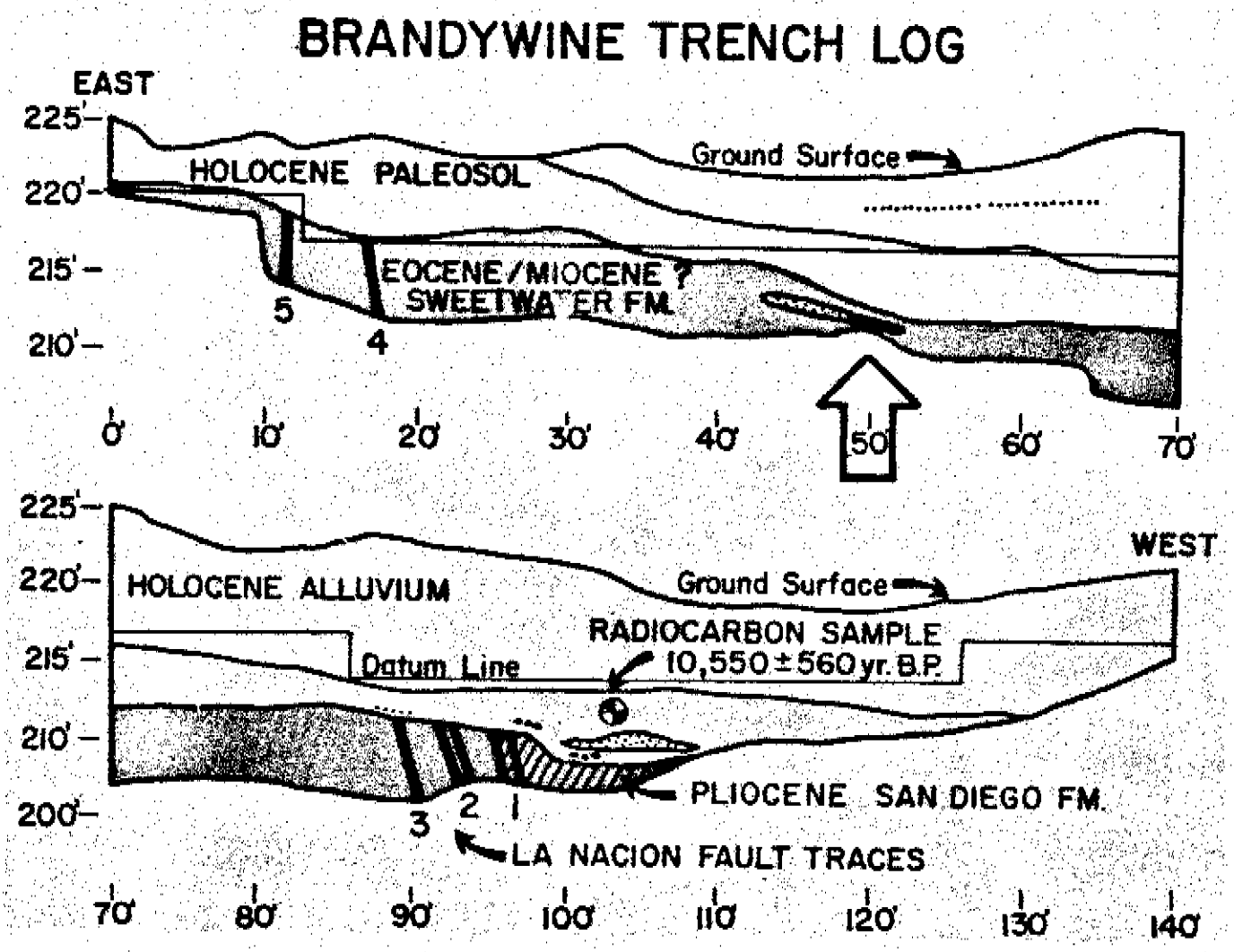

Figure 6. Simplified log of the south wall of the re-excavated Brandywine trench. The left member of trace no. 1 (the main trace) of the five La Nacion fault traces shown, separates the Eocene/Miocene? Sweetwater Formation from the Pliocene San Diego Formation. The location of the reported 1 meter (3 ft.) of offset of Holocene alluvium (Artim and Pinckney, 1973*a*, 1973*b*) is at station 50, indicated by the large open arrow. Neither the bedrock nor the overlying paleosol and alluvium are faulted at this location. None of the traces of the La Nacion shown offset is overlying Holocene paleosol or alluvium.

La Nacion fault. The head of the rock hammer in Figure 8 is approximately 2 inches to the left of the main trace.

The location of the reported offset Holocene alluvium, as shown on the original trench log, is approximately at station 50 (large open arrow on Figure 6). This portion of the trench was examined by each geologist present. The results of this investigation indicated that the there was no evidence of offset in the Holocene sediments or underlying bedrock at station 50. The irregular nature of the bedrock/paleosol surface at this location and elsewhere in the trench is best explained by scouring and channeling of the bedrock surface prior to deposition of the Holocene paleosol.

In conclusion, it has been determined that: (1) the La Nacion fault is overlain by unbroken Holocene deposits in the Brandywine trench, (2) the anomalous thicknesses of alluvium along the La Nacion fault trend reported in the Rice

Canyon area can be easily explained by non-tectonic processes (as opposed to Holocene movement on the La Nacion fault), and (3) Pleistocene age deposits (Lindavista Formation) have been offset by the fault, but Holocene deposits have not been offset. Therefore, the La Nacion fault should be considered potentially active (Assoc. Engineering Geologists, 1973).

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FER-82 Attachment #4
Hart, 1977, Figure 1
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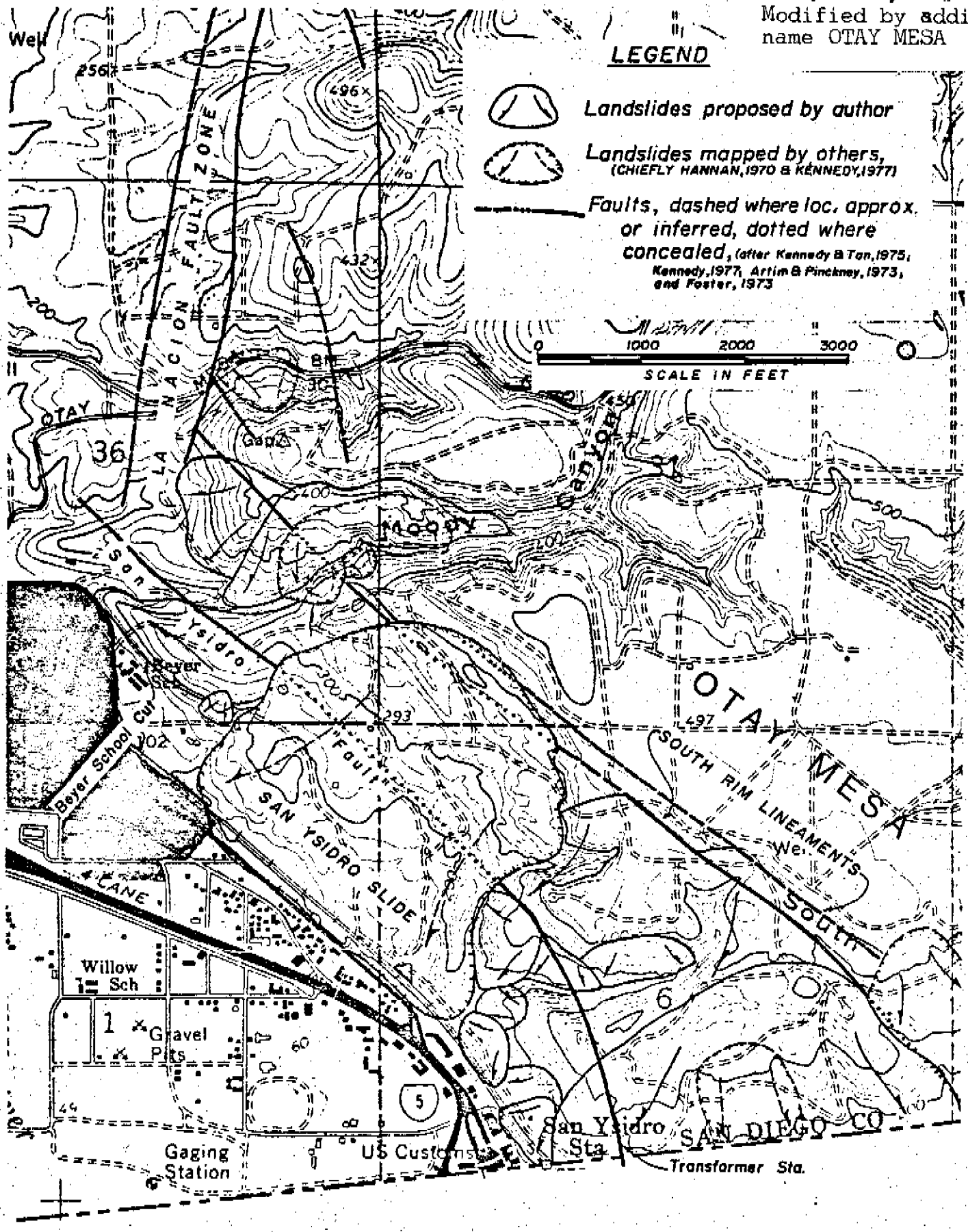

Figure 1. Fault and landslide map of San Ysidro area.